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XXVIII (1942)

PART I: BOTANY AND FORESTRY

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

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VOLUME XXVIII (1942)
PART I: BOTANY AND FORESTRY

"Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat."
— SENECA, *Naturales Quaestiones*

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BOTANY

NOTES ON HAWAIIAN FUNGI

ERNST A. BESSEY

OVER a large portion of the area of the Hawaiian Islands the fungous flora has undergone beyond doubt a very great change, although this cannot be demonstrated by comparison of earlier mycological collections with those more recent. The islands arose as a result of volcanic action in the floor of the Pacific Ocean at a depth of over three miles and at a distance of about 2,500 miles from the nearest continent. The first human settlements, so far as can be estimated, were made between 800 and 1,300 years ago by Polynesians coming in their outrigger boats from Tahiti or other island groups 2,000 to 2,500 miles distant. They brought with them pigs, dogs, and chickens and, as hitchhikers, rats, as well as coconut (*Cocos nucifera*), taro (*Colocasia antiquorum* var. *esculenta*), sweet potato (*Ipomoea batatas*), banana (*Musa spp.*), a small variety of sugar cane (*Saccharum officinarum*), and perhaps a few other plants. Neither the animals nor the plants they introduced had much effect upon the indigenous flora that had developed in the course of the millions of years since the islands had emerged from the depths of the sea.

When in 1778 Captain Cook found the Hawaiian Islands they were covered with their native vegetation, except for the numerous small fields planted to the introduced plants mentioned above and an occasional tree cut for use as timber or for making a canoe. There were no grazing animals, and the original cover of vegetation was practically undisturbed. By 1795 or a little later the whites had introduced horses, cattle, sheep, and goats, whose grazing rapidly led to the extermination of most of the native herbaceous plants and a large part of the shrubs and young trees in all accessible locations. Erosion of the denuded slopes and plains became very great. To make matters worse, the guava (*Psidium guajava*) and lantana (*Lantana camara*) were introduced and spread with great rapidity, soon covering the areas denuded by the grazing animals and crowding out

more of the native plants. Sod-producing grasses were brought in, such as Bermuda grass (*Cynodon dactylon*), Johnson grass (*Sorghum halepense*), and St. Augustine grass (*Stenotaphrum secundatum*), which assisted in the extermination of the few remaining native plants. The result is that until one goes into the hills to an altitude of 1,200 to 1,500 feet, and sometimes much higher, he sees only exotic vegetation. Even on the higher hills hundreds of species of woody plants have been introduced, so that only near and on the mountain tops is it possible to find pure stands of the original flora. This is especially true of Oahu Island.

The first collections of fungi were only incidental to those of vascular plants made by visitors to the islands in the first hundred years of the white man's knowledge of them. In 1895 A. A. Heller collected extensively, preparing for distribution several centuries of higher plants, and in addition picked up about two dozen species of fungi. Charles N. Forbes, botanist of the Bishop Museum in Honolulu for twelve or more years, made very numerous collections of higher plants, but also included (between 1910 and 1920) a good many of the higher fungi, some of which were identified by Dr. E. A. Burt (1), of the Missouri Botanical Garden. In 1921 Dr. F. L. Stevens spent four and one-half months on a Bishop Museum fellowship, principally upon the island of Oahu, but also visiting several other islands. He was particularly interested in the fungi that grow superficially, Meliolaceae, Capnodiaceae, etc., as well as in rusts, smuts, and a number of the smaller parasitic Pyrenomycetes. His report on his and earlier collections was published in 1925 (5). In the winter of 1927–28 Dr. C. L. Shear and Dr. Neil E. Stevens, of the United States Department of Agriculture, spent some months in the Territory, giving their attention chiefly to the Ascomycetes. The present writer was visiting professor of botany at the University of Hawaii from September, 1939, to June, 1940, and collected numerous specimens. Probably the most intensive studies of fungi have been made by Dr. H. L. Lyon and others of the staff of the Experiment Station of the Hawaiian Sugar Planters' Association and by the plant pathologists of the Hawaiian Experiment Station and of the Pineapple Producers Cooperative Association. As a result sugar cane, pineapple, and other economic plants have long lists of fungi that are found upon them as parasites and saprophytes. It should be noted that almost without exception these hosts are introduced plants. No

such study has been made of the fungous flora of any of the truly endemic Hawaiian plants. The slime molds, usually included among the fungi but almost certainly with no good reason, were the subjects of investigation by Dr. O. N. Allen, of the Department of Botany of the University of Hawaii. Dr. G. K. Parris, of the same institution, has published a check list and host index (4) of all the reported species of fungi from the region, a total of 729 species and varieties, including 99 slime molds.

It is very noticeable that the exótic woody plants, except those extensively cultivated, are usually freer from fungi than the native plants. Thus the native Metrosideros in the forests at the higher elevations is shown by Parris to have sixteen species of fungi, while the introduced and widely grown Eucalyptus has only six species, and the genus Casuarina, which is very widely planted, has no recorded fungi. The Hawaiian species of Acacia are credited with eleven fungi, and the closely related American Prosopis has but six. It is different when native and introduced herbaceous plants are compared, for the former have been driven back into the mountains and have not been examined for their fungous parasites as thoroughly as the latter species of the lower areas, since these include very many economic species or plants grown for ornamental purposes.

Turning now to the various groups of fungi, we find that many orders are not at all or only scantily represented among the reported fungi. Doubtless much of this apparent dearth of species in some groups is due more to lack of intensive search than to their actual absence. Thus the Chytridiales (in the older, wider, usage of the term) are represented by only two species, found in introduced cultivated plants, *Rhizidiocystis ananasi*, which kills the root hairs of the pineapple (*Ananas comosus*) and a suspected but unnamed fungus found by C. W. Carpenter (2) in the tissues of the stalks of sugar cane (*Saccharum officinarum*). In view of the widespread occurrence of members of this order in soil and water in temperate and tropical regions it is probable that it is actually better represented in Hawaii than the foregoing list would indicate. However, all the soil samples collected by the writer had to be fumigated before leaving Honolulu, and they did not reveal any chytrids when studied by Dr. F. K. Sparrow, of the University of Michigan. Of the Saprolegniales two species were trapped by the author by using sterile hemp seeds: *Achlya prolifera* and *Dictyuchus sterilis*. Since only a

few attempts were made to find these fungi they may well be more abundant. In the Peronosporales numerous species of Pythium and Phytophthora have been isolated and identified by the plant pathologists studying the various introduced economic plants. Only two Peronosporaceae have been reported: *Pseudoperonospora cubensis* on muskmelon (*Cucumis melo*) and cucumber (*C. sativus*) and *Peronospora effusa* on spinach (*Spinacia oleracea*), these three being introduced economic hosts. Two species of Albugo are known: *A. ipomoeae-panduranae* on an upland species of morning-glory (*Ipomoea indica*), but not on the sweet potato (*I. batatas*), and *A. candida* on cabbage and related Brassica species. The very abundant *Portulaca oleracea* is not attacked by *A. portulacae*, which is common on the North American mainland. Two species of *Entomophthora* have been reported, to which must be added *E. sphaerosperma*, found in 1940 on an introduced insect, *Pycnoderes quadrimaculatus*.

The Ascomycetes demonstrate how the special interest in particular families, as well as the conspicuousness of the specimens, leads to unevenness in the knowledge of the group as a whole. Dr. Roland Thaxter was interested in the Laboulbeniales and, without visiting Hawaii himself, made an intensive study of available collections of Hawaiian insects, with the result that he recognized six species of the genus Laboulbenia. The Xylariaceae are conspicuous fungi and, consequently, have been collected frequently. Dr. Shear and Dr. Neil E. Stevens were interested in the smaller Pyrenomycetes and found Diaporthe and related genera in abundance. Dr. F. L. Stevens, with his interest in the Meliolaceae, Capnodiaceae, and other more or less superficial Ascomycetes, found one hundred species of them, of which seventy-four were previously undescribed, including twelve new genera. Practically all these novelties were limited to hosts endemic in Hawaii. Stevens listed only five Discomycetes, but Miss Edith Cash in 1938 added thirty-four more, all but four of which were obtained by Shear and Neil E. Stevens. The writer's own collections add four more species to the list, making a total of forty-three species now known from that region.

Although the drier parts of the territory would seem to be well suited for Tuberales none have been found so far, nor have any of the Taphrinales been observed. Only the conidial stages were observed of the Erysiphaceae, as is true of this family in most tropical regions.

Thirty-nine species of the Uredinales were recorded by F. L. Stevens. Of the seventeen species collected by the writer only three were not in Stevens' list.

The Heterobasidiae (excluding rusts and smuts) are very abundant, but the number of species is not great. Burt records three species of Auricularia; the collection of the author added seven, in the Tremellaceae and Dacrymycetaceae.

The Corticieae are very abundant, but the number of species is not large. The Hydnaceae are represented by Radulum and one or two stipitate, long-toothed species. No Boletaceae have been reported. Clavariaceae are not common. Polyporaceae are well represented by the common genera. The native *Acacia koa* is host to quite a number of species of this family. Agaricaceae are mostly represented by wood- and bark-inhabiting species. The ground-inhabiting species are found in large numbers on lawns, parks, roadsides, and similar places, where the introduced turf-making grasses are well developed. Only once has the writer seen a specimen on the ground of the forest, and that was near the edge, where the illumination was good. In the wet forests the fallen twigs and branches bear Agaricaceae in fair abundance after a series of rains, but they do not occur on the ground. The ground is not covered by a thick humus layer, as it is in the woods of Michigan. After several days' rain numerous minute Marasmii, Pleuroti, and other agarics appear on the bark of various trees and on the reticulate leaf sheaths of the coconut, as well as on sugar-cane trash in the fields.

Gasteromycetes are not very common. A few species of Lycoperdon, Geaster, Mycenastrum, and similar genera were reported by Burt. *Phallus rubicundus* was reported by Cobb on sugar-cane roots over thirty years ago. To these the author has added a few others, including an apparently undescribed species of Pseudocolus. Tylostoma has been found by C. N. Forbes in drier portions of the Territory. It would seem probable that some of the genera characteristic of the dry regions of southern California, Arizona, and New Mexico may be found, but to determine this point will require a greater number of mycologists than now are available in Hawaii.

The Fungi Imperfecti are everywhere. Yet it is noticeable that a large number of species of higher plants are not found as hosts of any parasitic species of this group. Forms of Gloeosporium and Colletotrichum occur on injured and dying leaves of native and intro-

duced plants. In some cases they appear to be active parasites, but more often they are saprophytic or merely feebly parasitic on weakened tissues. The genera Septoria, Phoma, Phyllosticta, and Cercospora, among the strict parasites, are those in which the greater number of species occur. The common Penicillia and Aspergilli of world-wide distribution are found in abundance. A number of more strictly tropical Imperfect Fungi occur, but need further study.

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FURTHER STUDIES OF INHERITANCE OF VARIEGATION IN PETUNIA: BROKEN–VARIEGATED

ERNEST E. DALE

TWO types of flower variegation have thus far been reported in petunia: a mosaic form, by Malinowski and Sachsowa (1916, and Malinowski and others in later papers), and a reversible type, by Dale (1941). A variegation designated "stippled," by Dale (1942) appears to be the same as the mosaic type of Malinowski and Sachsowa. Crosses between the present variegation and "reversible" and "stippled" demonstrate that "broken-variegated" is a distinct genetic type. There are also ornamental varieties of the garden petunia with blotched, white and colored flowers, which are commonly called "variegated." Such strains studied by Malinowski (1914), Ferguson (1932), Harder (1934), Schröder (1934), and Levan (1939) do not have the mosaic character usually associated with variegation, and these unstable patterns, if they are to be considered variegations, are clearly of a special type. Indeed, the studies of both Harder and Schröder indicate that pattern development in these types is associated with temperature and light conditions. The blotched flowers appear to be transitional forms, the direction of change being environmentally controlled.

A strain of *broken-variegated* was obtained from Dr. W. C. Steere in 1929. Since that date variegated plants have been found twice in Michigan. One plant was discovered in a private garden near Ann Arbor, in 1933; the other came from a garden within the city, in 1935. In addition, a strain of petunia with green-edged flowers has occasionally produced broken-variegated plants. Intercrossing has shown that the variegation in these four strains is genetically identical. Since the variegated type has not, to the author's knowledge, been offered for sale by seed houses or grown as an ornamental its sporadic occurrence suggests either recurrent mutation or, possibly, some complex kind of segregation.

A flower of the broken-variegated type is illustrated in Plate I, Figure 1. Early in the season the flowers may have much less spotting than those borne later on the same plant. The combination of variegated and self-colored flowers growing side by side on different branches of the same plant, which is a striking feature of many variegations, does not occur in the broken-variegated strain, nor have self-colored plants been obtained from inbred seed of this type.

Routine counts of the chromosomes in pollen mother cells gave $n = 7$ in both *broken-variegated* and *green-edged*. These counts included observations of both anaphase groups of meiosis I for the variegated type. The aceto-carmine smear technique was used.

In crosses *broken-variegated* was recessive to both *white* and *colored*. Segregation in the F_2 and backcross differed markedly, depending upon whether the crosses were carried out in pink or purple strains (see Table I).

The results shown in Table I are so variable that it is worth noting that the data are from reciprocal crosses. Family 1472 clearly suggests recessive monohybrid segregation. The only other significant conclusion to be drawn from the table is that all the remaining families gave much lower proportions of *variegated* than would be expected on the basis of monogenic inheritance. This raises the question whether the results could be due to disturbed monogenic segregation resulting from some kind of modifying factors in the strains used. Accordingly, new crosses were made with a variegated, purple-flowered variety and a purple, self-colored strain. The F_2 and backcross data are given in Table II.

The F_2 and one backcross family conform to expectation for recessive monogenic inheritance, but one backcross family, 1771, departs significantly from expectation, the deviation being approximately three times the standard error. It is to be observed that the total figures for the backcross lie well within expectation for monogenic segregation. Since 1771 and 1779 are from reciprocal crosses and since the F_2 conforms so very closely to the expected proportions, it seems reasonable to conclude that *broken-variegated* is inherited as a monogenic recessive.

As mentioned earlier, a strain of petunia with green-edged flowers occasionally gave rise to broken-variegated plants. This form is illustrated in Plate I, Figure 2. All green-edged flowers, whether variegated or nonvariegated, are much reduced in size as

TABLE I

F_2 and Backcross Segregation of the Cross Pink, Broken-variegated × Pink, Self-colored in Petunia

F_2 Generation

Family number	Self-colored	Broken-variegated	Standard error
1472	75	19	
1475	90	3	
Total	165	22	4.4
Expected	140	47	

Backcross

1497	42	20	
1498	22	5	
1518	24	6	
1520	39	1	
Total	127	32	5.0
Expected	79.5	79.5	

TABLE II

F_2 and Backcross Segregation of the Cross Purple, Broken-variegated × Purple, Self-colored in Petunia

F_2 Generation

Family number	Self-colored	Broken-variegated	Standard error
1764.2 *	37	12	3.0
Expected	37	12	

Backcross

1771	125	84	7.0
1779	192	203	9.9
Total	317	287	12.3
Expected	302	302	

* The reciprocal cross did not produce viable seed.

compared with normal (nongreen) types. The history of the sporadic occurrence of such variegated plants is shown in Table III.

TABLE III

THE OCCURRENCE OF BROKEN-VARIEGATED PLANTS IN INBRED FAMILIES OF GREEN-EDGED IN PETUNIA

Family number	Year grown	Green-edged nonvariegated	Green-edged broken-variegated
776	1932	31	0
1169	1935	32	0
1326	1936	3	0
1327	1936	20	1
1454	1937	19	1
1587	1938	18	1
1604	1938	19	1
1697	1939	8	0
1792	1940	10	0
1841	1941	10	0

All the families of Table III were inbred, but the green-edged strain traces back to a cross between two green-edged plants which came from different sources. It is entirely possible that broken-variegated plants may have occurred in families 776 and 1169 and have been overlooked. For not until later did the author realize that *green-edged* occasionally segregated out the variegation, and 776 and 1169 were not specifically checked for variegations.

Crosses between the sporadically produced *green-edged, variegated* and the ordinary *broken-variegated* gave all broken-variegated progeny. When crosses were made between *broken-variegated* and *green-edged* (*nonvariegated*) the results shown in Table IV were obtained.

Since *broken-variegated* and *green-edged* are both recessive to *normal,* it was to be expected that all the F_1 progeny would be *self-colored.* The occurrence of variegation in the progeny shows that a factor for *broken-variegated* was contributed by the green-edged parent. Only one family, however, 1375, has a ratio approaching the 1 : 1 expected if the green-edged parent was heterozygous. It may be noted that the number of progeny indicates reduced fertility in this family.

Three pairs of reciprocal crosses are represented in the data of Table IV. Thus it is evident that a factor for variegation (from

TABLE IV

SEGREGATION IN THE F_1 GENERATION OF THE CROSS BROKEN-VARIEGATED × GREEN-EDGED IN PETUNIA

Family number	Flowers self-colored	Flowers broken-variegated
1375	5	7
1377	38	11
1617	39	11
1630	43	7
1719	48	6
1722	42	7
Total	215	49

green-edged) was readily transmitted through both the pollen and the ovules. It is possible that the green-edged parent may have been homozygous for the variegation factor. But this would require some kind of unstable suppressor mechanism which would normally prevent the expression of *variegated* in *green-edged* and would also occasionally give rise to variegated plants. How such a mechanism could operate the author is unable to explain.

The direction of change in *broken-variegated* is typically from dark- to light-colored. Anthocyanin in petunia flowers is borne in the floral epidermis. Since the broken-variegated plants do not segregate out self-colored flowers or produce self-colored from seed, the evidence suggests that somatic change in this type is phenotypical. But the possibility is not excluded that we are dealing with a genotypical variegation with mutation limited to the epidermal cells.

SUMMARY

1. In petunia broken-variegated flowers showed recessive monogenic inheritance in purple-flowered strains, but in pink-flowered strains gave wide departure from expectation.

2. A strain of petunia with green-edged flowers has occasionally segregated out broken-variegated plants.

3. Crosses between *broken-variegated* and *green-edged* gave about 19 per cent of *broken-variegated* in F_1.

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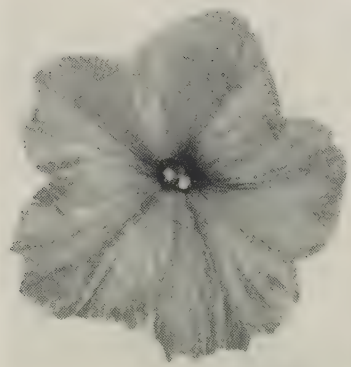

FIG. 1. *Broken-variegated* type of petunia flower

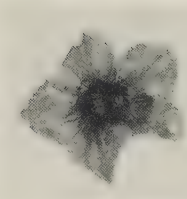

FIG. 2. Green-edged *broken-variegated* petunia flower

STUDIES ON PHILIPPINE CHLOROPHYCEAE. I
THE DASYCLADACEAE *

WILLIAM J. GILBERT

MEMBERS of the Dasycladaceae have been among the least reported of Philippine Chlorophyceae. According to the present knowledge of the writer, the first record of a plant of this family from the Philippines is that of *Polyphysa spicata* Kützing by Dickie (1876), the material having been collected at Mactan on the "Challenger" expedition. According to Solms-Laubach (1895, p. 31), in his "Monograph of the Acetabularieae," this was an incorrect determination, for he lists the same material under *Halicoryne Wrightii* Harvey, not *H. spicata* (Kützing) Solms-Laubach. A year later Dickie (1877) reported a collection of *Acetabularia Calyculus* Quoy & Gaimard from the harbor of Cebu. In 1913 Weber-van Bosse, in the first part of her *Liste des algues du Siboga*, cited both *Bornetella sphaerica* (Zanardini) Solms-Laubach and *B. oligospora* from the Sulu Archipelago. From then until 1932 there were no further definite records, but in that year Howe (1932) listed *A. major* Martens from Panay Island. There seems to be no other record of Philippine Dasycladaceae except a rather indefinite report of an Acetabularia by Solms-Laubach (1895, p. 23), who writes of seeing photographs of specimens of a plant that were "in Herb. Sloane sub 163, fol. 2, and 223, fol. 36," collected by Kamel in Luzon, and named *Androsaces Luzonis*. Because he had only photographs of the plant it was not possible to identify the species definitely, but Solms-Laubach indicates that it would seem to be either *Acetabularia major* Martens or *Acetabularia Gigas* Solms-Laubach.

The sources of material included in this study are largely the same as those mentioned in a previous paper by the author (Gilbert, 1942), except for the addition of a large number of specimens which

* Papers from the Department of Botany of the University of Michigan, No. 803.

were collected (in January and February, 1941) either by or under the direction of Professor H. H. Bartlett, of the University of Michigan, with the coöperation of the Zamboanga Office of the Philippine Bureau of Fisheries, through the interest and kindness of the chief, Mr. José Domantay. These were supplemented by material collected at Basilan Island by Mr. Liborio Ela Ebalo, of the Department of Botany, University of the Philippines.

Ten species of Philippine Dasycladaceae are discussed here. With the addition of *Acetabularia Calyculus*, which has been previously reported but is not found among the present collections, the number of species of Dasycladaceae from the Philippines is brought to eleven, six more than were previously known from this region. The species fall into five genera, two of which (Neomeris and Cymopolia) have not before been listed from the Philippines. A new species is proposed in Acetabularia. Of the ten species discussed in this paper the following are recorded from the Philippines for the first time: *Neomeris van-Bosseae*, *N. annulata*, *Cymopolia van-Bosseae*, *Bornetella nitida*, *Acetabularia dentata*, and *A. philippinensis*.

Systematic Account

The thallus of plants included in the Dasycladaceae is coenocytic (except during part of the life cycle of Acetabularia) and consists of a large, much-elongated, nonseptate, simple or, rarely, branched axial cell, which is attached to the substratum by means of rhizoids and which has numerous successive whorls of articulated, simple or ramified, lateral branches of determinate growth, that frequently bear deciduous hairs at their tips. The lateral branches may be modified in various ways, and in them or in structures to which they give rise gametes are formed directly or aplanospores are produced that are later transformed into gametangia. Zoospores and akinetes are unknown. Chromatophores are small, elliptical to lenticular, containing a single pyrenoid.

KEY TO THE GENERA

A. Lateral branches all of one kind, bearing 2 or more branchlets at their tips
  B. Aplanosporangia borne singly and terminally on primary branches between sterile branchlets ..... Neomeris, p. 17
  B. Aplanosporangia borne laterally on primary branches, 1 or more per branch ..... Bornetella, p. 21

A. Lateral branches of two kinds; all branches in a whorl of either the one or the other type
  B. Aplanosporangia borne singly at tips of fertile primary branches between branchlets; sterile branches simple and restricted to whorls clothing constricted parts of central axis ..... Cymopolia, p. 19
  B. Aplanosporangia produced by transformation of simple lateral primary branches; sterile branches always forking, not simple
    C. Whorls nearly covering axis, a whorl of sterile branches alternating with a whorl of fertile branches throughout .... Halicoryne, p. 27
    C. Lateral-branch whorls restricted to upper part of axis, usually being sterile except for a single terminal whorl of fertile branches often united in a disclike structure ..... Acetabularia, p. 29

NEOMERIS Lamouroux, 1816

These are calcified plants which are subcylindrical, clavate or subfusiform, consisting of a simple erect nonconstricted elongated axis that bears many closely set whorls of compound branches, each branch composed of a basal segment that gives rise at its tip to a stalked sporangium and 2 sterile branches which are inflated at their distal ends, with the swollen tips laterally coherent and forming a cortex; each of these cortical branches bears a deciduous branching hair at its tip. A calcareous capsule encloses each sporangium; it may or may not be coherent with adjacent capsules.

A. Calcareous capsules of sporangia not laterally coherent; fruiting portion not appearing annulate ..... 1. *N. van-Bosseae*, p. 17
A. Calcareous capsules of sporangia coherent, thus giving plant an annulate appearance in fruiting area..... 2. *N. annulata*, p. 19

1. *Neomeris van-Bosseae* Howe

Howe, 1909, p. 80, pl. 1, figs. 4, 7, pl. 5, figs. 17–19; Weber–van Bosse, 1913, p. 88; Setchell, 1926, p. 80.

The plants are gregarious, 1.0–2.4 cm. high and 1.5–3.0 mm. broad, subcylindrical to clavate, sometimes subfusiform, often curved near or above the middle. The erect axis gives rise to many successive whorls of primary branches, each whorl containing 30–40 branches, and each branch bearing at its terminal end a stalked sporangium and 2 secondary branches with capitate ends which are laterally coherent and which thus form the cortex. The branches of the first order are 350–710 μ long and about 34–51 μ broad in the lower half. The sporangia, including the stalks, are 180 200 μ long and contain a single globose oval spore 136–170 μ long and 120–

160 μ wide when mature. The thick calcareous coats around the sporangia are not laterally coherent, so that the sporangia are free from one another. Each branch of the second order bears at its tip a single branched septate deciduous hair. At the top of the thallus these hairs are not deciduous, but form a persistent apical tuft.

Distribution. — Malay Archipelago, Friendly Islands, Tahiti, Hawaii.

Collections. — *Curran, Forestry Bureau 11124,* Tayabas Province, Luzon, April. *Shaw 1151* and *1165*, Lamao, Province of Bataan, Luzon, May. *Velasquez 746*, west shore of *muelle*, vicinity of Puerto Galera, Mindoro, March; *851*, Medio Island, near Puerto Galera, Mindoro, April; *910*, Paniquian Island, vicinity of Puerto Galera, Mindoro, April; *1021*, San Teodoro Municipality, vicinity of Puerto Galera, Mindoro, April.

The material seems to agree very well with Howe's excellent description of *Neomeris van-Bosseae* (Howe, 1909, p. 80), the one significant difference being in the length of the first order of branches. At first the only materials at hand for study were the collections of Velasquez cited above, and it was noted in one collection (*Velasquez 910*) that, although the plants were mature, the length of the first order of branches varied from 350 to 430 μ, being much shorter than the 570–1000 μ ones in Howe's description; also, the plants appeared more slender than those with longer primary branches, though they still remained within the ratio of length to width which Howe has indicated for *N. van-Bosseae*. It was then decided that the difference in length of the first order of branches was not of form or varietal significance, for intermediate lengths were found on other specimens. It was interesting, therefore, to remark, sometime later, that Howe had called attention to a collection of *N. van-Bosseae* from Lamao, Bataan Province, the Philippines (*Shaw 1165*), with the following penciled note: "Much smaller than typical specimens and primary branches only 350–500 μ long; secondaries occasionally in 3's; but apparently not well separable from *Neomeris van-Bosseae*." Although the writer has not been able to find the secondary branches in threes, the specimens in *Velasquez 910* appear almost identical with those of the Shaw collection. It is apparent, therefore, that in *N. van-Bosseae* the primary order of branches may be considerably shorter than those previously described.

2. *Neomeris annulata* Dickie

Dickie, 1874, p. 198; Solms-Laubach, 1893, p. 62, pl. 8, figs. 1, 3–4, 7, pl. 8b, figs. 8, 12–13, 17; Børgesen, 1908, p. 272, figs. 1–2; Howe, 1909, p. 87, pl. 1, fig. 2; Weber–van Bosse, 1913, p. 88; Yamada, 1934, p. 51, figs. 16–17; Tseng, 1936, p. 158, fig. 19.

The plants are either gregarious or scattered, 9–15 mm. high and 1–2 mm. broad, subcylindrical or fusiform. The thallus consists of an erect simple axis giving rise to many successive whorls of branches; the branches number about 38–44 per whorl and each bears at its terminal end a stalked sporangium and 2 branches of a second order that have capitate ends which are laterally coherent, thus forming the cortex. The arrangement of these secondary branches is such that there are twice as many transverse rows of facets in the cortex as there are whorls of primary branches. Each branch of the second order bears at its tip a branched septate deciduous hair. The branches of the first order are 220–290 μ long and 12–16 μ wide in their lower parts. The sporangia, including the stalks, are 160–185 μ long and 54–74 μ broad; they contain a single oblong to obovoid spore 122–140 μ long and 45–70 μ broad. The sporangia are strongly calcified, and the thick coating around the spores is coherent with the capsules of groups of other sporangia, so that characteristic interrupted calcareous transverse rings are formed in the fruiting parts.

Distribution. — Bermuda, Florida, West Indies, Indian Ocean, Malay Archipelago, China Sea (Hainan), Friendly Islands.

Collections. — *Velasquez 746a,* west shore of *muelle,* vicinity of Puerto Galera, Mindoro, March; *910a,* Paniquian Island, vicinity of Puerto Galera, Mindoro, April.

Each of the collections above is represented by a single specimen found mixed with *Neomeris van-Bosseae* in two of the collections cited under that species, namely, *Velasquez 746* and *910.* The two specimens were removed from those collections, transferred to different envelopes, and designated *Velasquez 746a* and *910a,* respectively. The material agrees well with the more complete descriptions of Howe (1909, p. 87) and others.

CYMOPOLIA Lamouroux, 1816

These are plants with a simple or branching thallus made up of a series of calcified, more or less moniliform segments connected by a

series of uncalcified "internodes." The calcified segments consist of an elongated central axis (running the whole length of the plant) that gives rise to a number of successive whorls of branches, each branch bearing at its top a sessile sporangium and several corticating branches. The corticating branches extend beyond the sporangia and have capitate ends that are more or less coherent, thus providing a covering for the sporangia and forming a unistratose cortex. Between the calcified segments the axis is constricted and gives rise in this region to several successive whorls of short simple sterile branches. Branching of the axis takes place in this uncalcified portion. The thallus is terminated by a tuft of branched hairs.

Cymopolia van-Bosseae Solms-Laubach

Solms-Laubach, 1893, p. 78, pl. 8b, figs. 9–10, 15–16; Weber–van Bosse, 1913, p. 89; Yamada, 1934, p. 52, figs. 18–19.

The thallus is simple, clavate, as much as 1.3 cm. in height although usually shorter, and segmented, the segments being 4–9 in number. Near the base of the plant the segments are about 1 mm. broad and 1 mm. long; they increase in size toward the top of the plant, so that the upper ones may reach 2 mm. in diameter and 1.3 mm. in height. The central axis is unconstricted for a short distance near the base of the plant, but constricted above, being 180–280 μ broad at the constrictions and 320–465 μ broad in the segments between the constrictions, usually with a greater diameter in the wider segments above. The central axis bears 8–18 successive whorls of fertile branches in each of the calcified segments, the number of whorls being only 8–12 in the lower segments. Each whorl consists of 17–26 branches. The primary or first order of branches are 184–450 μ long (the upper segments having the longer branches) and 20–54 μ broad; each gives rise at its terminal end to a single sessile sporangium and 4–9 corticating branches. The corticating branches are 198–312 μ in length and their capitate ends 54–68 μ wide, more or less coherent but separating rather easily after decalcification. In each of the internodes, between the calcified segments, there are 5 or 6 successive whorls of short simple sterile branches that are 84–136 μ long, numbering about 12–18 per whorl. The sporangia are globose or obovate, 170–240 μ long and 156–190 μ wide.

Distribution. — Malay Archipelago, Liu-kiu Islands.

Collection. — *Bartlett 14143*, Santa Cruz, Zambales Province, Luzon, May.

So far as the writer is aware, this is but the fourth record of this species in the literature. It has heretofore been reported in the Netherlands East Indies from Maumeri on the north coast of Flores Island (Solms-Laubach, 1893) and from several stations on the "Siboga" expedition (Weber–van Bosse, 1913). A third occurrence is recorded from the Liu-kiu Islands (Yamada, 1934). The detailed description above was occasioned by the fact that there seems to be no earlier morphological study that includes much more than the general features, measurements being given only for the height of the plant and the diameter of the sporangia. Yamada (1934, fig. 18) and Solms-Laubach (1893, pl. 8b, figs. 15–16) have produced two excellent habit sketches of the species. Weber–van Bosse (1913, p. 89) reports that the plant reaches a height of 1.5 cm.

This is the only species of Cymopolia found in Pacific waters, and it seems to be restricted to the region of the Malay Archipelago, southern Japan, and the Philippines, although the minuteness of the plant may have resulted in its being generally overlooked. It is to be readily distinguished from the only other known species of the genus, *Cymopolia barbata* (L.) Lamouroux, which is found in Florida, the West Indies, and the Canary Islands. The latter species reaches a height of 1–2 decimeters and branches; it differs also in the size of the corticating cells and sporangia and in the relative lengths of the simple sterile branches and the compound fertile branches, as well as in a number of other ways. Solms-Laubach (1893, pp. 78–79) has already given a good comparison of the two species.

BORNETELLA Munier-Chalmas, 1877

These are plants with globose or clavate, simple, more or less stipitate thalli. In structure they are composed of a central erect axis that gives rise to many successive whorls of long cylindrical branches which bear, laterally, from 1 to many aplanosporangia and which are terminated by 3–8 short inflated truncate branches that are laterally coherent and that form a unistratose cortex which is slightly calcified. When present, the stipe is the downward continuation of the central axis and branches irregularly at its lower end to form a small holdfast.

A. Thallus globose or oblong, 1 cm. or less in diameter .. 1. *B. sphaerica*, p. 22
A. Thallus subcylindrical to clavate, sometimes curved, 1.5–4 cm. long

B. One or 2 aplanosporangia formed on each primary branch; 8–60 spores per sporangium ..... 2. *B. nitida*, p. 25
B. From 4 to many aplanosporangia formed on each primary branch, often crowded; 2–8 spores per sporangium ... 3. *B. oligospora*, p. 26

1. *Bornetella sphaerica* (Zanardini) Solms-Laubach

Neomeris sphaerica Zanardini, 1878, p. 38; *Bornetella sphaerica* (Zanardini) Solms-Laubach, 1893, p. 92, pl. 9, fig. 8; Weber-van Bosse, 1913, p. 90; *B. ovalis* Yamada, 1933, p. 277; 1934, p. 51, figs. 14–15.

The thallus is spherical or oval, often shortly stipitate, up to 1 cm. in breadth, although usually considerably smaller. The stipe, when present, reaches 1–2 mm. in length and branches irregularly below to form a small holdfast. The central axis is 0.5–1.0 mm. broad, cylindrical or slightly tapering to a rounded apex, extending about half the length of the frond, and bearing 11–14 successive whorls of long narrow cylindrical primary branches. There are in each whorl 14–22 primary branches 106–140 μ broad, increasing at their outer ends to 180 μ, and terminated by 4–7 short, capitate branches, the inflated ends of which are 284–500(625) μ broad, truncate, laterally coherent, and calcified, making up a unistratose cortex. From 4 to 12 aplanosporangia are borne laterally on a primary branch, usually on the outer half of the branch, but sometimes scattered over the whole length; they are spherical, 210–300 μ broad when mature, and contain 4–16 aplanospores that are 94–136 μ broad and more or less spherical, with a slightly stratified wall about 5 μ thick (see Fig. 1a–b).

Distribution. — Malay Archipelago, Liu-kiu Islands.

Collections. — *Villaflores 33*, Lubang Island, Province of Mindoro, Sept. *Balhani 772*, Sangig, Takut Tangug Bay, southwest of Matangal Point, east coast of Basilan Island, Jan.–Feb.

This interesting species is represented by two Philippine collections, which clearly show the spherical or ovoid thalli and the characteristic spherical sporangia and spores. *Bornetella sphaerica* cannot easily be told from *B. capitata* (Harvey) J. Agardh except in dealing with fruiting material, when a section through the thallus will quickly reveal which species is present, for *B. capitata* is characterized by oval or oblong sporangia and somewhat smaller, more or less ovoid, thick-walled spores (see Fig. 1c–d). The writer has studied specimens of *B. capitata* from the Thousand Islands near Batavia, Java,

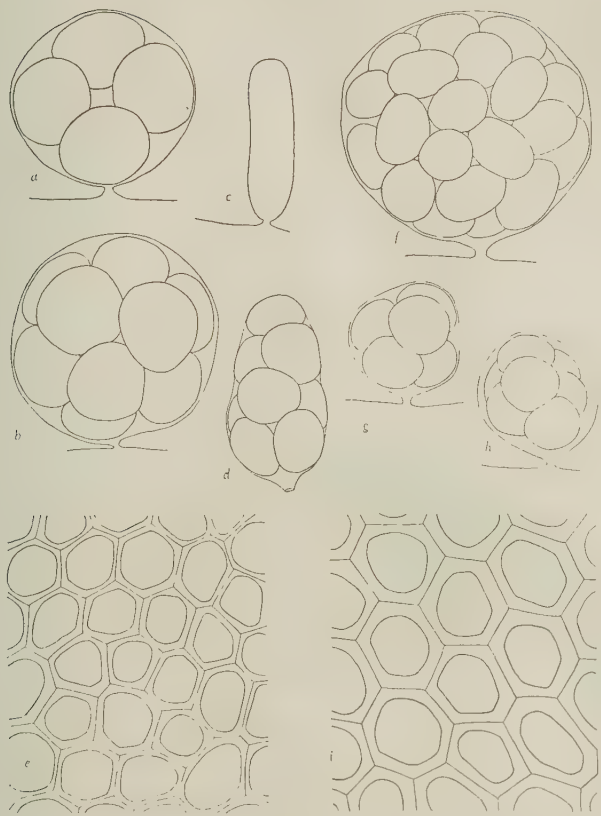

FIG. 1. *Bornetella spp.: a–b, B. sphaerica* (Zanardini) Solms-Laubach, aplanosporangia containing aplanospores, × 118. *c–d, B. capitata* (Harvey) J. Agardh; *c*, an immature aplanosporangium; *d*, a mature aplanosporangium; both × 118. *e–f, B. nitida* (Harvey) Munier-Chalmas; *e*, surface view of cortex after decalcification, showing the thickened ring of wall material in the radial walls of the cortical branches, × 54; *f*, a mature aplanosporangium, × 118. *g–i, B. oligospora* Solms-Laubach; *g–h*, mature aplanosporangia, × 118; *i*, surface view of cortex after decalcification, showing the thickened ring of wall material in the radial walls of the corticating branches, × 54

and wholly agrees with Weber–van Bosse (1913, p. 90) that it and *B. sphaerica* are different species. There is every reason to believe that *B. capitata* may also be found in the Philippines, even though it does not appear in the present material.

A question arises, however, as to the similarity of the Philippine specimens of *Bornetella sphaerica* to *B. ovalis* Yamada (1933, p. 277), the latter having been proposed as a different species from *B. sphaerica* on the ground that its thallus was shortly stipitate and that the aplanosporangia were produced on the upper part of the primary branches near the periphery of the thallus, whereas in *B. sphaerica* the frond was supposed to be sessile and the sporangia were generally distributed over the length of the primary branches. With regard to the first point, it is interesting to note that, although *B. sphaerica* was originally described as sessile, Solms-Laubach (1893, p. 90) has pointed out after studying a specimen of the original material that the specimen had apparently been carelessly collected and that the base was broken off, leaving a large opening into the lumen, so that, after drying, the material appeared to be sessile, a point which Yamada may have overlooked. One is impressed with the tenaciousness with which the holdfast clings to the corals on which this species grows, and often, unless one uses extreme care in collecting, the stipe is torn away from the main body of the thallus. So true is this of the Philippine material that only about one specimen in three has a short stipe; the other stipes were evidently broken off, and the fronds appear to be sessile. Upon careful examination one can see the torn lower end of the central axis in these "sessile" specimens, not to mention that there is a complete lack of any sort of attaching organs, the presence of which would be necessitated were the fronds actually sessile.

The other point of difference, the position of the sporangia, is only a minor one. It appears that in general most of the sporangia are borne on the upper part of the primary branches in *Bornetella sphaerica*, but at times intermediate conditions are evident in which the sporangia are pretty well spread along these branches. It is worth pointing out that the drawing of *B. sphaerica* in the paper by Solms-Laubach (1893, pl. 9, fig. 8), on which Yamada apparently based his opinion that the sporangia were generally distributed over the whole primary branch (not having seen any authentic ma-

terial himself), is described by Solms-Laubach as an "etwas schematisches Habitusbild" of a specimen, and does not claim to be wholly accurate. It seems probable then that *B. ovalis* Yamada should be considered synonymous with the previously described *B. sphaerica* (Zanardini) Solms-Laubach.

2. *Bornetella nitida* (Harvey) Munier-Chalmas

Neomeris nitida Harvey, 1857, List of Friendly Islands Algae, no. 83; *Bornetella nitida* (Harvey) Munier-Chalmas, 1877, p. 816; Cramer, 1891, p. 22, pl. 3; Solms-Laubach, 1893, p. 80; Weber–van Bosse, 1913, p. 89.

The thallus is subcylindrical to clavate, more often the latter; it is sometimes shortly stipitate, as much as 3.0 cm. high, 3–7.5 mm. broad, and, usually, curved. The central axis is 600–700 μ broad and more or less cylindrical, with a rounded apex; it extends nearly the whole length of the frond and is slightly constricted between the many whorls of long narrow cylindrical primary branches. The number of whorls varies greatly with the height of the plant, but appears always to be more than 60. Each whorl has 24–30 primary branches. These are 27–45 μ broad, increasing to 90 μ at their swollen terminal ends, where they give rise to 4–7 short capitate branches that are 110–240 μ broad. The thickened ring of the radial walls in the capitate branches is up to 20 μ thick, although it may be as much as 50 μ thick in the lowest part of the plant. These capitate branches are laterally coherent and calcified, and make up the cortex (see Fig. 1e). There are only 1 or 2 spherical aplanosporangia formed laterally on each primary branch; they are 160–320 μ broad when mature and contain 8–60 oval aplanospores 78–122(136) μ long and 57–68 μ wide, with a pitted wall 3–6 μ thick (see Fig. 1f).

Distribution. — Friendly Islands, Australia, Malay Archipelago.

Collection. — *McGregor 63*, Bohol Island.

It was at first with uncertainty that this collection was identified as *Bornetella nitida*, for although in most respects it seemed to agree well with material of that species there were one or two points of difference which were troublesome. It has previously been thought that in *B. nitida* the aplanosporangia were produced only singly on the primary branches, and indeed this was one among other reasons for separating from it *B. oligospora*, which has several

sporangia per primary branch. It was disturbing, therefore, to find 2 sporangia (though not more) on a number of the branches in the Philippine material. In addition, many of the sporangia on reaching maturity produced only 8–16 spores, in contrast to the 24–67 originally described for *B. nitida*.

Through the kindness of Dr. F. J. Seaver, curator of the Cryptogamic Herbarium at the New York Botanical Garden, the writer was able to borrow isotype material of *Bornetella nitida* (Harvey's Friendly Islands Algae, no. 83, sub *Neomeris nitida*) and was several times able to demonstrate the presence of a second sporangium on a primary branch. When only a single sporangium occurs it is regularly situated about 270–300 μ from the outer end of the branch; the second one usually develops farther in, near the middle of the branch. It is only seldom that both these sporangia are seen together on a branch, because the sporangia are very caducous, especially when mature. One must look for scars left by the sporangia, and these are usually more clearly perceived after the material has been boiled in a weak solution of potassium hydroxide. In addition, many of the sporangia in the Friendly Islands specimens produced only 8–16 spores (the usual number in the Philippine material), although many others produced the much larger number usually accredited to the species.

3. *Bornetella oligospora* Solms-Laubach

Solms-Laubach, 1893, p. 81, pl. 9, figs. 1–4, 6–7; Weber–van Bosse, 1913, p. 89.

The thallus is subcylindrical to clavate, sometimes slightly curved, up to 4 cm. in height and 4–6 mm. broad, occasionally shortly stipitate. The central axis is about 1.0–1.25 mm. broad, cylindrical, extending nearly the whole length of the frond, and not at all constricted between the whorls of branches. It gives rise to many successive whorls of long narrow cylindrical primary branches, numbering 27–32 per whorl. These branches are 70–100 μ broad, increasing to 120 μ in width at their terminal end, where they bear 4–7 short capitate branches, the inflated ends of which are 156–284 μ broad, with the thickened ring on the radial walls 30–58 μ wide. The secondary branches are laterally coherent, calcified, and form a unistratose cortex (see Fig. 1i). There are 4–12 spherical aplanosporangia produced laterally on each primary branch; they are

120–170 μ broad when mature and contain 2–8 oval to spherical aplanospores. The spores are 55 100 μ broad, with a pitted wall that is 5–10 μ thick (see Fig. 1 g–h).

Distribution. — Malay Archipelago.

Collection. — *Merrill 9153*, Taytay, Palawan, April.

So much alike from an external view are *Bornetella oligospora* and *B. nitida* that it is scarcely possible to tell them apart unless a microscopical examination of their internal anatomy is made. In mature plants *B. nitida* has only 1 or 2 sporangia per primary branch, borne on the outer part of the branches; these sporangia are larger and produce more spores than the numerous, smaller, more generally distributed sporangia of *B. oligospora*. It is observed also that the very young sporangia of *B. nitida* are somewhat oval, in contrast to the young spherical sporangia of *B. oligospora*. Another apparently quite constant character separating the species is the width of the thickened ring in the radial walls of the cortical branches, the ring being 30–58 μ wide in *B. oligospora* and 10–25 μ wide in *B. nitida*. In *B. nitida* the calcification seems to be less heavy and the surface of the thallus less shiny than in *B. oligospora*.

HALICORYNE Harvey, 1859

These plants are calcified, clavate, and have a simple erect axis on which are produced many whorls of branches of two types, a whorl of sterile branching tufted hairlike branches alternating with a whorl of simple, sporangial, pod-shaped vesicular branches. The fertile branches are usually imbricate and cut off from the erect axis by a thin basal wall; on the upper side, not far from the axis, they bear a small protuberance, separating the upper aplanospore-bearing portion from the more or less cylindrical base. The spore membranes are thick and heavily calcified.

Halicoryne Wrightii Harvey

Harvey, 1859, p. 333; Dickie, 1876, p. 243 (as *Polyphysa spicata*); Agardh, J., 1886, p. 159, pl. 5, figs. 1–5; Cramer, 1895, p. 18, pl. 1, figs. 1–9; Solms-Laubach, 1895, p. 31, pl. 4, figs. 4–5, 8, 10; Okamura, 1908, p. 217, pl. 43; Yamada, 1934, p. 59, fig. 26.

The thallus is simple, clavate, erect, 4–8 cm. high, with the central axis sometimes naked for a short distance at the base of the plant. The stemlike "naked" part may be as long as 2.5 cm., but it bears

scars of branches which have dropped off, the scars being of two sizes, the smaller ones corresponding to whorls of sterile branches and the larger to whorls of fertile branches. The whorls of 3–4 times polychotomous sterile branches are always produced a little above the middle of the distance between the fertile whorls; they number 8-16 per whorl, and are persistent only in the upper part of the plant. The fertile branches number 12–16 (20) per whorl, are 2.0–2.3 mm. long, usually imbricate, and rarely widely spreading. In each of the fertile branches 16–30 aplanospores 150–200 μ broad are produced. The spore membrane is radially striated, 17–30 μ thick, and heavily calcified. The spores remain entirely free from one another.

Distribution. — Liu-kiu Islands, Philippines.

Collections. — *Bartlett 14039, 14040, 14041,* Subic Bay, Zambales Province, Luzon, May. *Albatross Expedition 13,* Subic Bay, Zambales Province, Luzon, Jan. *Shaw 497,* Lamao, Bataan Province, Luzon, May. *Albatross Expedition 12,* Cauanhala Bay, Ragay Gulf, Albay, Luzon, March. *Robinson 6709,* Bulalacao, Mindoro, March. *Albatross Expedition 11,* Mogas Point, Panay, Feb. *McGregor 82,* Bohol Island.

This very interesting material of *Halicoryne Wrightii* Harvey is mostly fruiting. It is interesting to note that the fertile branches are not extended at right angles to the main axis, or reflexed, as has been so often reported, but that they are imbricate, even in the older parts of the plants. Okamura (1908, p. 217) has already mentioned that the fertile branches of specimens of *H. Wrightii* from the Liu-kiu Islands are imbricate.

The other species of this genus, *Halicoryne spicata* (Kützing) Solms-Laubach, was reported from the Philippines by Dickie (1876, p. 243), but his determination appears to have been incorrect, for Solms-Laubach (1895, p. 31), having studied the same material, cites it in his "Monograph of the Acetabularieae" under *H. Wrightii,* with the notation that it is "young and sterile." *H. spicata* has been reported only from Australia, New Caledonia, and three localities at Flores Island, but it would not be unreasonable to expect it in the Philippine flora. It can be differentiated from *H. Wrightii* in that the fertile branches of *H. spicata* reach a length of only 1.3 mm. and have fewer spores than do those of *H. Wrightii.* The spores in *H. spicata* form a mass in the sporangium because their calcified membranes are coherent.

ACETABULARIA Lamouroux, 1812

These plants consist of an erect stalk that bears at its upper end a single disclike cap (rarely from 2 to several successive caps), and below the cap, in the upper part of the stalk, from 1 to several whorls of branched deciduous hairs. The cap is composed of many radial segments or rays, which are either free or laterally coherent and which, when mature, contain the aplanospores. On the upper and lower sides of the cap, near the stalk attachment, are 2 cushion-like rings, the upper known as the corona superior, and the lower (absent in some species) as the corona inferior, each being made up of radial segments corresponding in number and position to the rays of the disc. The segments of the corona superior bear a number of deciduous branched hairs or 1-celled hair prominences. The deciduous hairs are represented by a scar when they have fallen off.

A. Side walls of sporangial rays with vertical notched processes that give them a striated appearance; caps 15–22 mm. broad .. 1. *A. major*, p. 29
A. Side walls of sporangial rays smooth, without notch ribs; caps under 10 mm. in width
  B. Sporangial rays with apiculate margin; hair prominences or scars 3–4 on each segment of the corona superior ..... 2. *A. dentata*, p. 30
  B. Sporangial rays blunt, with no apiculum; hair prominences or scars 5–7 on each segment of the corona superior 3. *A. philippinensis*, p. 31

1. *Acetabularia major* Martens

Martens, 1866, p. 25, pl. 4, fig. 3; Solms-Laubach, 1895, p. 22; Yamada, 1925, p. 89; Howe, 1932, p. 169.

The plants are gregarious and reach a height of 4–6 cm. The stalk is heavily calcified, cylindrical, and does not swell in the region of hair-scar whorls; it bears at its summit a single, flat, slightly calcified cap 1.3–2.2 cm. broad and composed of 70–74 sporangial rays held together because of the deposition of lime. The rays separate rather easily after decalcification and have (especially on the inner half) vertical notched processes on their side walls. The apices of the rays are blunt or, rarely, somewhat emarginate (see Fig. 2a). The corona superior is 200–225 μ broad, with the segments rather narrow and not united; each segment has 7–9 hair prominences or scars in a uniseriate row (see Fig. 2b). The corona inferior is 184 210 μ broad, with segments rounded or, rarely,

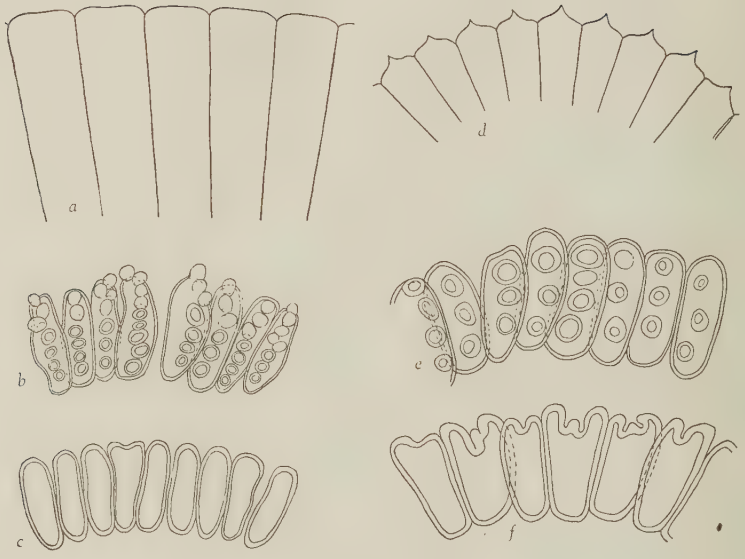

FIG. 2. *Acetabularia spp.: a–c, A. major* Martens; *a*, part of the outer portion of the cap after decalcification, showing the apices of the disc rays, × 16; *b*, a few segments of the corona superior, showing the hair scars and hair prominences, × 68; *c*, a few segments of the corona inferior, × 68. *d–f, A. dentata* Solms-Laubach; *d*, part of the outer portion of the cap after decalcification, showing the apiculate apices of the disc rays, × 22; *e*, a few segments of the corona superior, showing the hair scars, × 148; *f*, a few segments of the corona inferior, × 148

emarginate (see Fig. 2c). The aplanospores are oval, 78–88 μ long and 64–75 μ wide, completely filling the rays.

Distribution. — Thailand, Timor, New Guinea, Philippines.

Collections. — *Bartlett 14042*, Subic Bay, Subic, Zambales Province, Luzon, May; *14144*, Santa Cruz, Zambales Province, Luzon, May. *Albatross Expedition 62.*

2. *Acetabularia dentata* Solms-Laubach

Solms-Laubach, 1895, p. 23, pl. 1, fig. 11; Yamada, 1934, p. 54, fig. 21.

The plants are gregarious and small, reaching a height of only 1–2 cm. The stalk is rather heavily calcified and cylindrical, with or without a single whorl of hair scars just below the single, some-

what saucer-shaped, rather heavily calcified cap. The cap is 1–4 mm. broad and is made up of 28–38 sporangial rays that are not coherent laterally but are held together by the deposition of lime. The rays are apiculate, not often rounded, but usually elevated into a pyramid-like shape at their apical ends (see Fig. 2d). The corona superior is 110–125 μ broad, composed of crowded but laterally free ovate segments, which bear 3–4 hair prominences or scars in a uniseriate row (see Fig. 2e). The corona inferior is 95–120 μ broad, and is composed of rather crowded segments that are distinctly bilobed or, rarely, trilobed at their outer ends (see Fig. 2f). The material is sterile.

Distribution. — New Caledonia, New Guinea, Celebes, Liu-kiu Islands.

Collection. — *Bartlett 14988*, Dalupiri Island, Babuyan Group, Oct.–Nov.

The material agrees well with Solms-Laubach's analysis of the species, differing only in the matter of lobing of the outer end of the segments of the corona inferior. In the collection at hand the ends of the segments are occasionally trilobed, instead of regularly bilobed, as in the original description. Some of the specimens, however, show only bilobed ends on rays of the corona inferior, and those which have ends that are trilobed are never uniformly that way, the trilobed ends always being mixed with bilobed ones.

3. **Acetabularia philippinensis,** sp. nov.

Plantae gregariae, 2–4.5 cm. altae. Frons e stipite valde incrustato et filiformi et leviter incrustato disco composita. Discus solitarius, diametro 3.5–6.0 mm., fere planus, ex 50–67 fertilibus radiis compositus, eisdem elongate clavatis, lateraliter ex basi usque ad apicem liberis, apice rotundatis vel subtruncatis, haud apiculatis; segmentis coronae superioris 140–184 μ longis, inter se liberis, ovatis, pilis 5–7 uniseriatis instructis; segmentis coronae inferioris 155–170 μ longis, ovatis, inter se liberis, externe raro rotundis, saepe emarginatis vel profunde bilobatis.

Specimen typicum: *E. D. Merrill 9123*, ex Taytay, Palawan, Insulis Philippinis, mense Aprili, 1913; in Herbario Horti Botanici, N. Y., conservatum.

The plants are gregarious, 2–4.5 cm. in height. The stalk is heavily calcified, narrow and cylindrical except for slight spindle-

shaped swellings at the 2–6 whorls of hair scars situated in the upper half of the stalk below the single cap which is borne at the summit. The cap is slightly calcified, 3.5–6.0 mm. broad, and flat or nearly so. The sporangial rays, numbering about 50–67, are held together only because of the deposition of lime, and fall apart upon decalcification; they have rounded or, rarely, truncate apices (see Fig. 3a). The

Fig. 3. *Acetabularia philippinensis*, sp. nov.: *a*, part of the outer portion of the cap after decalcification, showing the rounded or subtruncate apices of the disc rays, × 18; *b*, a few segments of the corona superior, showing the hair scars and hair prominences, × 123; *c*, a few segments of the corona inferior, showing the emarginate to deeply bilobed outer ends, × 123; *d*, a radial-longitudinal section of part of the disc, showing the corona superior (with one hair scar, the base of a hair, and several hair prominences), the proximal end of a disc ray, and, at the bottom, the corona inferior, × 123

corona superior is about 140–184 μ broad, and is composed of longish ovate uncrowded segments bearing 5–7 hair prominences or scars in a uniseriate row (see Fig. 3b, d). The corona inferior is 155–170 μ wide and composed of more or less crowded ovate or slightly wedge-shaped segments, which, at their external ends, are simple, emarginate, or deeply bilobed, often with the lobes asymmetrical in size (see Fig. 3c–d). The plants are sterile.

Collection. — *Merrill 9123* (TYPE), Taytay, Palawan, April, 1913, in the Herbarium of the New York Botanical Garden.

This new species of Acetabularia belongs to the Acetabuloides section of the genus, probably being nearest to *Acetabularia ryukyuensis* Okamura and Yamada (Okamura, 1932). The two species are about the same height and have about the same number of noncoherent rays with truncate or slightly rounded external margins. The new species differs from *A. ryukyuensis* in the cap, which is less broad, as well as in the character and size of the coronae. The segments of the corona superior in *A. ryukyuensis* are oblong, about 250 μ in length, "with 5-6 (mostly 5) hair scars in one row," whereas in *A. philippinensis* the segments are longish-ovate, 140 184 μ long, and bear 5–7 (usually 6) crowded hair prominences or scars in a uniseriate row. In *A. ryukyuensis* the segments of the corona inferior are much shorter than those of the corona superior, and they are oblong, with a rounded external end. They thus contrast with the segments of the corona inferior of *A. philippinensis*, which are approximately of the same length as those of the corona superior and oblong to wedge-shaped, with the outer ends simple, emarginate, or, more often, deeply bilobed.

From other related acetabularias that have no apiculum or vertical notches on the sporangial rays *Acetabularia philippinensis* differs even more decidedly. The numerous sporangial rays with rounded or truncate external margins, the large number of hair protuberances or scars on the segments of the corona superior, and the deep lobing of many of the segments of the corona inferior set it apart from *A. Calyculus* Quoy & Gaimard and the rather questionable species *A. Suhrii* Solms-Laubach, both of which have fewer rays per disc, those rays being emarginate at their apices, with only 2–4 hair prominences or scars on each segment of the corona superior. It is likewise sharply set off from *A. Farlowii* Solms-Laubach, which is not known from Pacific waters. The latter species has only about 30 sporangial rays to a disc, these rays being free, not held together by calcification. In addition, it has but 2 hair scars per segment of the corona superior.

Acetabularia Calyculus Quoy & Gaimard has been listed from the Philippines by Dickie (1877, p. 489), although it does not appear in the collections at hand. The writer has had no opportunity to view the material reported by Dickie, but has no reason to doubt the

correctness of the determination. It may be recognized by its small size, its deeply emarginate sporangial rays, of which there are 22–30 per disc, held together only because of the deposition of lime, and by the oblong to oblong-triangular segments of the coronae, those of the corona superior bearing only 2–3 hair scars.

The genus Acetabularia appears to be very inadequately represented in the Philippine collections, for in addition to the four species discussed above there are at least eight that can be expected in this area. Several of these are extremely small. Forms like *Acetabularia Moebii* Solms or *A. pusilla* (Howe) Collins, which are only 2–4 mm. high, may be easily overlooked, especially by someone whose acquaintance with algae is limited and who does not suspect the presence of such minute forms. A search for these small acetabularias and a more thorough collecting of the larger types ought to reveal a number of species not at present known from the Philippines, and, possibly, several new forms.

The writer wishes to express his thanks to Dr. Wm. Randolph Taylor, professor of botany, University of Michigan, under whose direction the present studies have been carried out.

University of Michigan

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ADDITIONS TO THE FLORA OF MICHIGAN. IV

CLARENCE R. HANES

COLLECTIONS made mainly in 1940 and 1941 by Mrs. Florence N. Hanes and the writer in Kalamazoo County, Michigan, are listed in the present paper. Specimens of most of these have been deposited in the herbaria of the Bailey Hortorium, the University of Oklahoma, and the National Arboretum, at which institutions their identification has been confirmed. At the end of the list of species three corrections are made of plants given in previous papers with incorrect determinations.

An asterisk is used to indicate those species which are, so far as is known, new to Michigan.

List of Species

Sparganium minimum Fries. — Small pond southwest of Pretty Lake in Section 20, Texas Township, September 22, 1941, no. 7241.

Apparently this station extends the range southward in Michigan. The pond is usually full of water, but in September, when specimens were collected, it was almost dry. Many mature seeds and remnants of plants were seen.

Potamogeton Robbinsii Oakes. — Shallow water near the east shore of Austin Lake, August 5, 1941, no. 13641; August 14, 1941, no. 13841.

This pondweed must be erratic in its habits of growth since the summer of 1941 was the first season we saw it here, although it has been our custom for the past six years to visit this lake several times during the summer months, when the westerly winds bring the loosened plants ashore.

Panicum Bicknellii Nash. — Wooded roadside in Section 36, Climax Township, June 20, 1938, no. 778; November 7, 1938, no. 1398.

Both Mrs. Agnes Chase and Mr. J. R. Swallen have referred

our specimens to *P. Bicknellii*, although they are not quite typical.

ERIOPHORUM TENELLUM Nutt. In Le Fevre Bog, Section 8, Climax Township, June 18, 1941, no. 13441.

It is easy to classify this species wrongly, for it is very similar to *E. gracile*, from which it differs in the color of the scales and the much greater length of the leaves. We find no records for the Southern Peninsula of Michigan.

SCIRPUS SYLVATICUS L. Border of swamp in Section 6, Oshtemo Township, July 27, 1940, no. 440, and on the border of Little Portage Creek in Section 31, Wakeshma Township, August 12, 1941, no. 16741.

This is an Atlantic Coastal Plain species rarely found inland. I am considering this one of the two recent reports for the state, although it is listed by Beal[1] as from Keweenaw County. This report was, no doubt, based upon a collection of *S. rubrotinctus* Fern., which is plentiful there. Since Kalamazoo County is in the section of the state where there are many Atlantic Coastal Plain species we may reasonably expect to find the plant in southwestern Michigan, but not in the Upper Peninsula. Hebert[2] has a report for Berrien County, which is also in southwestern Michigan.

Fred W. Rapp of Vicksburg made a collection of this plant in August 23, 1941, in Section 10, Brady Township.

*JUNCUS BIFLORUS Ell. f. ADINUS Fern. & Grisc. – Sandy shore on the east side of Austin Lake, August 5, 1941, no. 6541.

Deam[3] gives only one location for this form — in Indiana. Our specimen was checked by F. J. Hermann.

*ARABIS HIRSUTA (L.) Scop. var. ADPRESSIPILIS (Hopkins) Rollins (*A. pycnocarpa* Hopkins var. *adpressipilis* Hopkins). – East of Galesburg, near the Kalamazoo River, June 6, 1940, no. 110.

The range map of Milton Hopkins[4] does not give this variety from Michigan.

*RUBUS MEDIOCRIS Bailey. Swamp border in Section 28, Portage

[1] Beal, W. J., "Michigan Flora," *Annual Rep. Mich. Acad. Sci.*, 5: 52. 1904.

[2] Hebert, P. E., "Ferns and Flowering Plants of Berrien County, Michigan," *Am. Mid. Nat.*, 15: 327. 1934.

[3] Deam, C. C., *Flora of Indiana* (Indianapolis, 1940), p. 296.

[4] Hopkins, Milton, "Arabis in Eastern and Central North America," *Rhodora*, 39: 117. 1937.

Township, August 5, 1941, no. 3041, and also in Section 10 of this same township, August 21, 1941, no. 3441.

This is a new species, described and published in 1941 by L. H. Bailey.[5] The two stations given above are the only ones from which it has been reported to the present time. The type specimen, no. 3041, is in the Bailey Herbarium, and the isotype is in the Hanes Herbarium.

*Oxalis europaea Jordan var. Bushii Small, f. vestita Wieg. — Wood border in Section 3, Cooper Township, August 27, 1941, no. 14741.

Of the several forms of this species variety *Bushii* seems to have good enough characters to sanction its retention.

*Croton monanthogynus Michx. — Open woodland near the south shore of Wyman Lake, Oshtemo Township, July 23, 1941, no. 7041.

It is difficult to understand how this plant was brought to the place where we found it. It surely is not native to our state. Deam speaks of its weedy nature. Though not yet abundant it has become scattered over a small area.

*Verbascum phlomoides L. — Roadside one mile west of Schoolcraft, near the McCreary farm, August 18, 1941, no. 15741.

It is still rare in our county, since only one plant has been found.

*Coreopsis tripteris L. var. Deamii Standl. — Wood border in Section 8, Charleston Township, August 21, 1941, no. 15941.

This variety has also been found on the west side of the county near Wyman Lake. It often grows with the species, but is readily distinguished from it even at a distance by its darker green color.

Schoolcraft, Michigan

[5] *Gentes Herbarum*, 5: 191–192. 1941.

LIST OF CORRECTIONS FOR PREVIOUS PAPERS

STELLARIA CRASSIFOLIA Ehrh. — This species was reported in 1938 as *S. borealis* Bigel.[6] Since the petals are usually present and are longer than the sepals it should be referred to *S. crassifolia.*

ERYSIMUM PARVIFLORUM Nutt. — Wrongly reported in 1938 as *E. asperum* DC.[7]

*COREOPSIS GRANDIFLORA Hogg. — Incorrectly reported in 1937 as *Thelesperma trifidum* (Poir) Britt.[8] We know of no previous records for this species from Michigan.

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[6] Hanes, Clarence R., "Plants New or Rare in Michigan Records," *Pap. Mich. Acad. Sci., Arts, and Letters,* 24, Part I (1938): 6. 1939.

[7] *Ibid.,* pp. 6–7.

[8] Hanes, Clarence R., "Additions to the Flora of Michigan," *Pap. Mich. Acad. Sci., Arts, and Letters,* 23 (1937): 139. 1938.

POLLEN ANALYSIS OF A SWEDISH BOG NEAR LAKE STOR-UMAN

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and

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POLLEN statistical studies are more complicated in America than in northern Europe because of the much larger woody flora which must be taken into consideration. The European results seem to an American so definite and conclusive that it is natural to wonder whether a study of a Scandinavian locality, particularly if the data are in accordance with those currently obtained by Scandinavian workers, might not give one a feeling of confidence in his own methods and conclusions.

With the greatly appreciated advice of Dr. Gunnar Erdtman a bog was selected for study in the summer of 1938. It is near Lake Stor-Uman, in the southern part of Swedish Lapland, approximately twenty miles south of the Arctic Circle (Fig. 1). The location was sufficiently different from others already studied by Swedish scientists for the results to be used as a small contribution to the body of data on pollen analysis. At the same time, if the findings should be clearly in line with those already published, the study would have a psychological value as well in showing that our procedures in America are comparable and our interpretations valid.

The mountain ranges of Sweden extend from north to south. On the eastern side of the range are many lake basins that resulted from glaciation. Of these, Lake Stor-Uman, with an area of sixty-five square miles, provided the focus for study. To the south of the lake lies Rönnliden State Forest, within which the bog is situated at about 65 N. latitude and 17 E. longitude. The bog itself is in a slight depression below the Baktisjaur hut, at the edge of a miniature

lake known as Lake Fetögat. The region is somewhat higher than Lake Stor-Uman, rising four hundred and twenty-five meters above the sea.

The edge of the bog consisted of sphagnum and herbaceous plants, and a large percentage of ericaceous plants, such as *Vaccinium uliginosum* L., *V. Myrtillus* L., *V. Oxycoccus* L., *Calluna vulgaris* (L.)

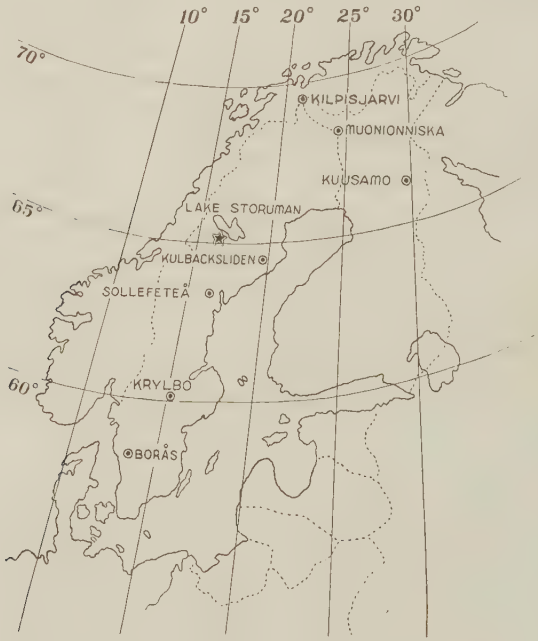

Fig. 1. Location of the bog near Lake Stor-Uman and of others previously investigated by Swedish scientists

Hull., *Eriophorum alpinum* L., *Carex pauciflora* Lightf., *Rubus Chamaemorus* L., and *Scheuchzeria palustris* L. Growing away from the edge were *Picea excelsa* var. *obovata*, *Pinus silvestris* var. *lapponica*, *Betula nana* Willd., and *Salix glauca* L., with the mostly herbaceous cover including *Drosera rotundifolia* L., *D. longifolia* L., *Pinguicula vulgaris* L., *Vaccinium Vitis-Idaea* L., *Parnassia palustris* L., *Menyanthes trifoliata* L., and *Empetrum nigrum* L.

The texture and composition of the peat indicated that the deposit had been built from the ground up, with a constantly rising water table. In other words, at the point where the samples were taken, there had not been an original open water surface on which subaërial peat had formed. The rise of the water table over a whole area owing to bog growth throughout the region would cause the flooding of some areas that were not originally either boggy or open water. Such flooded areas in which peat growth did not keep up with the general rise of the water table would serve to stabilize the gradually rising water table of the bog, since drainage (seepage) could take place in either direction. Such conditions appear to exist at the locality chosen for our study, since there is near it a pond with a

Fig. 2. Pollen profile of the bog near Lake Stor-Uman

drowned peat bottom. This pond had no floating mat, for the footing was solid to the water's edge.

The samples were taken with a Davis peat borer or sampler, beginning at the one-foot level and continuing until glacial clay was reached at the eleven- and twelve-foot levels.

Four slides, prepared according to the method suggested by Dr. Erdtman (1), were made from each foot of material, the general process being that of maceration by alternating mild oxidation and acid hydrolysis. One hundred and fifty pollen grains were counted for each of the ten feet. The samples from the eleventh and twelfth feet consisted of barren glacial clay.

Counting the top sample as the first and continuing downward, we obtained the following results (Fig. 2): Pine was found in increasing amount from the tenth upward to the eighth sample, where it reached its maximum, and from there decreased up to the first,

where there seemed to be a slight increase. Spruce was represented in the tenth layer by only a single grain and showed an increase to its maximum in the second layer, with a very slight decrease at the top. The count for Betula showed a steady drop from the tenth to the first layer. Alnus, abundant at the tenth layer, diminished until only a single grain was found in each of the samples from the first and second layers. There is now no Alnus in the living flora. The ground-cover plants represented in the peat were almost entirely Ericaceae, and their abundance increased decidedly toward the surface, especially in the first three layers.

We find that the results obtained from the study of the Stor-Uman bog conform, in general, with those of other bogs in northern Sweden, as given by Godwin (2) and Von Post (3). This bog lies between Sollefteå and Kulbacksliden, where other bogs have been examined and where similar pollen spectra have been obtained for publication (Godwin, 2, p. 334). In each of these Pinus indicates an increase at the middle and a decline toward the top, with a slightly larger number near the surface. In both, spruce, which is represented by a few grains at the bottom, shows a decided increase at the top.

The Alnus profiles of the bogs are all similar, having a decided decrease from the bottom layers to a complete absence or only an occasional grain at the top. In the upper layers of the Stor-Uman bog the Betula profile does not conform with that for the other two bogs, since in both there is an increase near the surface, whereas in the Stor-Uman bog there is a decrease.

The results of our analysis of a Swedish bog are therefore in agreement with those obtained by Swedish workers. We had wondered what the result of following a definite and accepted tradition in the technique and interpretation of pollen analysis in Europe might be, and, in particular, whether the European peats, examined in the light of American experience, would really prove to be so much simpler in composition than those in America. We found that American peats are actually much more complex, and that the conclusions of European scientists are not based upon oversimplification. Although this was what had been expected, it has, nevertheless, given us greater confidence in the application of the Swedish techniques to our more complex materials. It is likewise of some little value as an addition to the records of Swedish bogs, many of which have been investigated by Erdtman and others.

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FOREST ASSOCIATIONS OF OTTAWA COUNTY, MICHIGAN, AT THE TIME OF THE ORIGINAL SURVEY

LESLIE A. KENOYER

WHEN the land of southwestern Michigan was surveyed for settlement, in the 1820's and 1830's, the surveyor recorded by name two reference trees selected at each section corner and at the mid-point of each section boundary. Copies of field books of the survey are on file at each county seat. After indicating at the proper points on a county map the species of reference trees recorded by the surveyor one can outline with considerable confidence the forest distribution at that time. Woodlots now standing are so fragmentary that, though in the main they agree with the surveyor's record, they present a less accurate picture of the former distribution of associations.

In three papers previously presented before the Academy (1, 2, 3) the writer mapped and discussed the distribution, indicated in the survey, for nine of the counties of southwestern Michigan. In May, 1941, he examined the field books of Ottawa County and mapped the associations. This county lies just to the north of Allegan County, one of the group previously studied, and borders Lake Michigan on the west. It was surveyed in the years 1831 to 1834.

In the earlier studies the associations were designated as beech-maple (often including hemlock), oak-hickory, oak-pine, prairie with scattering bur oak, lake, and swamp. Hemlocks were entirely and pines mainly restricted to the counties bordering Lake Michigan, where, also, beech and maple were most extensive. Prairies were limited to the two southern tiers of counties. Oak-hickory and prairie associations are not found in Ottawa County. There are two areas that seem to be prevailingly pine and oak, and several relatively small swamp areas. It most closely resembles Allegan County, but exceeds that county in the proportion of beech, maple, and hemlock. A comparison of the two is given on page 49, the figures representing percentages.

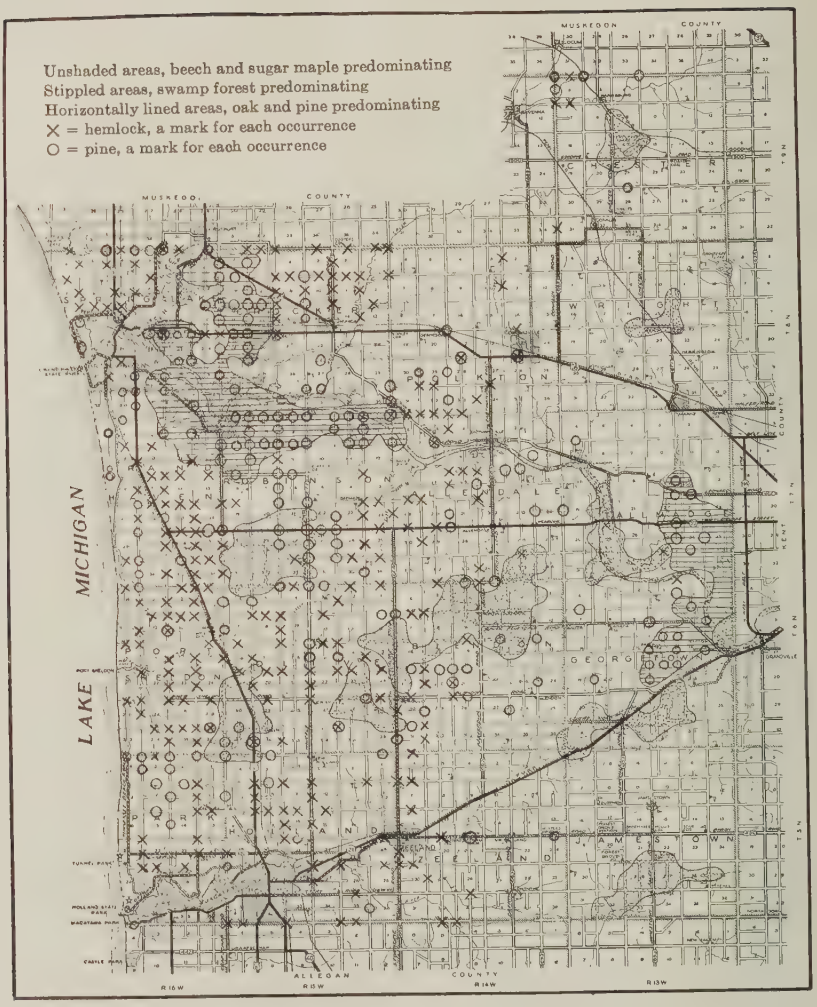

Fig. 1. Forest map of Ottawa County, Michigan

Forest Associations of Allegan and Ottawa Counties

Associations	*Allegan*	*Ottawa*
Beech-maple (with hemlock, especially in the half nearest the lake)	69	85
Oak-pine	16	7
Oak-hickory	8	0
Lake and swamp	7	8

Of the trees marked by the surveyor as bearing trees, usually two at each section corner and two at the middle of each section boundary, the most frequent species are, in percentages of the whole number:

Beech	33.7
Hemlock	13.5
Sugar maple	12.5
Pine (species not designated)	8.6
Black and white ash	7.3
All oaks	5.1
Soft maples	5.0

It is obvious from Figure 1 that hemlock and, to a somewhat lesser extent, pine (species not indicated) were more abundant in the portion of the county nearer Lake Michigan. A strip twelve miles broad next to the lake includes about half of the area of the county, about five sixths of the hemlocks recorded as reference trees, and about three fourths of the pines.

Noteworthy features of Ottawa County, as compared with the more southerly area, Kalamazoo and the adjoining counties, are the absence of grassland areas, the scarcity of oaks, and the extreme scarcity of hickories. Another evident fact is the less definite indication of boundaries between the associations. There is more of a tendency for certain species to be scattered over the various environments in the area.

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REGENERATION IN *RADICULA AQUATICA* *

CARL D. LA RUE

MANY papers have been published on regeneration of plant parts. Among them are those on leaves, by Kupfer (4), La Rue (5), Loeb (10), and Stingl (13); on stems, by Goebel (2), Kupfer (4), Loeb (10), and Vochting (14); on roots, by Beals (1), Graham and Stewart (3), Kupfer (4), Naylor (12), and Vochting (4); and even on flowers and fruits, by Goebel (2), Kupfer (4), and La Rue (9). So large, indeed, is the number of such papers and so many are the species treated in them that the addition of another title to the list would not be worth recording did it not concern a species of unusual capacity both for vegetative reproduction and for true regeneration. The lake cress, *Radicula aquatica* (Eat.) Robinson, is a species of this character.

Brief examination of a thriving colony of *Radicula aquatica* in midsummer is all that is needed to convince one of an extremely high rate of propagation of this species by vegetative means. Further acquaintance shows that it has remarkable ability to regenerate new buds and roots from all its parts, which is rather surprising in a plant with a highly specialized method of vegetative reproduction. It is a plant so highly propagative that few others can equal it in this respect, and it deserves more than the brief notice it has already received (6, 7, 8).

HABIT AND HABITAT

Radicula aquatica is an aquatic herbaceous perennial belonging to the Cruciferae; it is closely related to the water cress, *Radicula Nasturtium-aquaticum*, and to the horse radish, *Radicula Armoracia*.

The species is widespread throughout the northeastern United States, and once established in a stream it becomes extremely abundant, but it is known to the author from only a few localities. It produces a small number of seeds, and its method of reproduction is

* Papers from the Department of Botany of the University of Michigan, No. 808, reporting work done at the University of Michigan Biological Station.

better suited for local spread than for long transportation. Whether this or a special habitat or a combination of the two accounts for its rather infrequent occurrence is not yet known.

Streams four to six feet deep with mucky bottoms are favored by this species. Young plants grow in shallow water and even on wet muck above the water, but do not thrive there. The stem bases of mature plants remain alive in the muck over the winter, after the upper parts have died and rotted. In the spring the side buds grow out from the old stems and produce rosettes of leaves, which are much branched and very finely divided.

Later in the season the stems grow upward rapidly through the water. As they ascend the leaves formed in succession are less and less divided, and those produced near the surface of the water are only slightly lobed. The leaves that are formed above the water surface are entire or barely notched. This variation of leaf form in relation to differences in depth of immersion in water is even more extreme than that described by McCallum (11) for *Proserpinaca palustris*.

The rosette leaves are long-petioled and have numerous long filamentous tips. Those formed on the stem immediately above the rosette have short petioles and show a well-developed midrib, from which great numbers of branched segments arise. Above these leaves come a series which have numbers of toothlike lobes that are unbranched. This lobing becomes less and less pronounced as the stem nears the surface of the water until, as has been said, it emerges from the water and bears entire leaves on its upper portion.

As seen from above, the basal rosettes in the water are tufted and very handsome, but the emerged stems are weedy and unkempt in appearance from the loss of the aërial leaves, which fall off at the slightest touch.

Microscopic sections show abscission layers at the bases of the leaves. On the emerged leaves these are well developed, and nearly all the leaves except the very young ones are soon broken off. Downward from the surface of the water one finds the abscission layer less developed in each successive leaf. The rosette leaves, which are not easily detached, ordinarily remain on the plant until winter, or even until early in the following spring. If one pulls a plant up from the muck he usually finds that only the youngest leaves at the tip of the stem and the rosette leaves at its base remain attached.

In the vicinity of Cheboygan, Michigan, where the following studies were made, some of the plants begin flowering in early August, but not many fruits form, and it appears that few of these can ripen before the early frosts kill them. Ripe seeds have never been found in that locality, and it seems likely that, in latitudes so far north at least, the species depends mainly on vegetative propagation for its distribution.

VEGETATIVE REPRODUCTION

It has been found that buds are produced on the stems in the axils of the leaves and also beyond the abscission layer in the petioles themselves. Consequently, when the leaves break off from the stem they leave one or more buds at each node of the stem and bear two or three buds in the base of each petiole. Since the plants grow in water the leaves fall on its surface, and the buds begin growth. Within a week several roots have appeared on each petiole, and a shoot has started from one of the buds. As the new plant grows the leaf from which it has sprung begins to die. Finely divided leaves appear to perish earlier than entire leaves, but both types persist for some time after the new plants have been formed.

Vast numbers of new plants are produced in streams where *Radicula aquatica* is abundant, and the surface of the water is covered with tons of leaves and young plants. Some of the young plants drift out to the stream banks and attach themselves to the mucky soil there; more of them drift down the streams and out into the lakes or larger streams, where they are lost; still others sink to the bottom of the water as the leaves which formed them decay and as the weather grows colder and cloudier. Thus these little plants serve as hibernacula, and if they do not root on the bottom during the winter they float up to the surface with the advent of more intense sunlight in spring, and continue their journey.

Roots and shoots do not always develop with equal rapidity on these leaves. Buds usually grow out most rapidly when the leaves float on water, but roots form more rapidly on leaves laid on moist filter paper in closed glass containers. This is clearly shown in Table I.

Vegetative propagation of this plant takes place in nature also when stems are broken off, or bitten off, from their bases. The buds at the nodes then grow out, forming shoots which produce roots at

their bases and mature into new plants. For convenience details of the development of stem buds will be treated under the topic of "Regeneration."

TABLE I

Root Formation in Water and on Moist Paper

Type of leaf	No. of leaves	Substratum	Number of roots formed		
			In 4 days	In 8 days	In 12 days
Whole leaves	20	In water	8	36	36
	20	On moist filter paper	28	75	75
Leaves with bases of petioles cut off to remove preformed buds	20	In water	..	3	7
	20	On moist filter paper	..	20	33

REGENERATION

Regeneration is now usually distinguished from vegetative reproduction, and the term is applied to the formation of new buds and roots, whereas the production of plants from preformed buds is considered to be merely vegetative multiplication. In the preceding paragraphs the usual means of propagation of the plant has been discussed. In some sections of the treatment of regeneration examples may be given which technically belong under vegetative propagation, but it seems more convenient to group them in such a way as to show the actual behavior of the parts rather than to be meticulous as to the separation into proper categories.

Regeneration in Leaves

When the bases of leaves are cut off — and thus all preformed buds are removed — regeneration of roots and buds takes place. Roots are formed within eight days, as is shown in Tables I and II. Bud regeneration takes longer, but within two weeks most of the petioles will have formed new buds.

The regeneration of roots on disbudded leaves, like root formation on whole leaves, occurs more rapidly on moist paper than in water, as Table I indicates.

The vegetative outgrowth of roots on whole leaves appears to be slightly inhibited by light, but, on the contrary, light is beneficial to regeneration of roots on disbudded leaves. If, however, growth hormones are applied to the leaves in lanolin the effect of light is lost. Table II is representative of a series of experiments on the effect of light and of growth hormones.

TABLE II

THE EFFECTS OF LIGHT AND OF GROWTH HORMONES ON ROOT FORMATION ON LEAVES

Type of leaf	No. of leaves in each set	Number of roots formed in 8 days					
		In light			In dark		
		Untreated	2 % indole acetic acid	2 % indole butyric acid	Untreated	2 % indole acetic acid	2 % indole butyric acid
Whole leaves	20	51	65	119	81	71	128
Leaves with bases of petioles cut off to remove preformed buds ...	20	15	14	65	2	28	45

Mutilated leaves and parts of leaves regenerate buds readily, but only in light. Since bud formation is slower than root formation, it is to be expected that it would be less successful in the dark than in the light because of the etiolation of the leaves during the period they are kept in darkness. As is shown by trials, the leaves do not keep in good condition in the dark long enough to regenerate buds.

Leaves cut into narrow slices from base to tip, with enough of the lamina left intact at the tip to hold the slices together, will form buds and roots at the base of the petiole and wherever cuts have severed large veins. If the slices are made in a similar manner, but from tip to base, regeneration rarely occurs in whole leaves. The preformed buds in the petiole appear to inhibit bud formation elsewhere. If the petioles are disbudded, buds will form at the base of the petiole and along the cuts where large veins have been severed.

If leaves are cut into slices 2–3 mm. wide in a crosswise direction

and only enough of the lamina is left intact on one side to hold the slices together, many of the slices will form buds and roots on their lower edges. Neither buds nor roots are formed on the upper edges of the slices. If the petioles are disbudded, more of the slices will regenerate and do so more rapidly. The inhibiting effect of the preformed buds is thus shown, even though the path of any inhibiting substance must travel through a narrow channel along the uncut margin of the leaf and sidewise through the slices. Buds and roots on the slices are usually formed on the cut midribs, but sometimes they are on the lower ends of the larger veins.

Midribs of leaves from which the lamina have been removed, whether disbudded or not, behave almost like whole leaves, but show somewhat weaker growth. Crosswise and lengthwise slices of leaves only 2 mm. wide have formed new buds and roots.

The smallest piece of leaf known to regenerate was the tip of one of the filamentous divisions of a submerged leaf. It was only 1 mm. in diameter and 5 mm. long, but it formed a bud on the cut base.

Regeneration in Stems

On stems growing naturally in the water branching does not occur. Late in the season short roots grow out from many of the nodes below the water surface, after the leaves have fallen. The buds at these nodes usually elongate slightly, and then remain completely inhibited, unless the stem tip has been removed.

Pieces of stem containing ten nodes were cut, with stem tips and clusters of terminal leaves intact on them. Kept in damp chambers on moist paper, they promptly formed roots at the lower nodes, but no shoots at all.

Similar stems with stem tips and all leaves removed formed a strong shoot at the terminal node of each, a small shoot at each of the two next lower nodes, and no shoots at any other node. Roots were formed at five or six nodes of the basal end.

Stem pieces with fewer nodes behaved in the same way. Even a half stem with two nodes produced at the upper node a strong shoot which inhibited the growth of a shoot from the lower node.

Pieces of stem with two nodes were split from the top down almost to the base, with the cut running between the buds on these nodes. Shoots grew out from both nodes of these pieces.

Lengthwise slices of stem, halves, quarters, or slices of cortex,

provided they bear buds, act in the same way as whole stems. A thin lengthwise slice of cortex through one node and parts of the adjoining internodes produced a shoot from the bud at the node.

Crosswise slices, only 1 mm. thick, through nodes of stems 1.5 mm. in diameter have produced shoots from nodal buds.

In view of the strong inhibitory effect which terminal shoots exercise over the buds below them on the stem an experiment was set up to test the effect of growth hormones as bud inhibitors. In each set twenty stems were used, all of the same length, of comparable size, and containing approximately the same number of nodes. Counts were made at the end of eight days. The results are shown in Table III.

TABLE III

The Effects of Growth Hormones on Root and Shoot Formation on Stems

Treatment	Stems without leaves		Stems with leaves	
	Roots	Shoots	Roots	Shoots
In light	398	37	477	37
In light, with 2 % indole acetic acid in lanolin	633	14	333	21
In light, with 2 % indole butyric acid in lanolin	693	12	678	20
In darkness	520	48	398	43
In darkness, with 2 % indole acetic acid in lanolin	963	16	622	15
In darkness, with 2 % indole butyric acid in lanolin	1280	0	549	0

Table III shows a strong stimulation of root formation by the growth hormones, as Table II indicates for leaves. It is rather interesting that both indole acetic acid and indole butyric acid are able to produce additive effects in a plant already very potent in root formation.

Both hormones are able to inhibit shoot growth, but only indole butyric acid was able to inhibit it completely, and that only in the dark.

In another experiment pieces of stem were cut to uniform length. In one group a single node was included in each stem piece; in the

other the pieces consisted of internodes only. All the segments were kept on moist paper in glass damp chambers. Twenty stem segments were used in each set. The data, which were taken at the end of fourteen days, are presented in Table IV.

TABLE IV

The Effects of Growth Hormones on Root and Shoot Formation on Nodes and Internodes

Treatment	Nodes		Internodes	
	Roots	Shoots	Roots	Shoots
Controls	9	16	0	0
2 % indole acetic acid in lanolin	56	16	11	0
2 % indole butyric acid in lanolin ...	126	0	57	0

As shown in Table III, only indole butyric acid is able to inhibit buds completely. Indole acetic acid does not appear to inhibit the buds on single nodes. Both of the growth hormones stimulate root growth at the nodes and induce root regeneration on the internodes.

All the preceding results with stems, except the data on internodes in Table IV, may be considered mere vegetative multiplication, since the buds were present at the beginning of the trials. But the stems are capable of true regeneration. Segments of stems from which the nodal buds have been cut out are able to regenerate new buds on the cut surfaces. Also, pieces of stem containing three nodes which have been divested of all cortical tissue and all buds as well will form new buds at the nodes. Pieces of internode, after some delay, will regenerate buds from vascular bundles on the basal end. Table IV shows that such internodes will form roots rather readily if stimulated by growth hormones, but such root formation has been secured without their use by putting pieces of internode in sterile culture on nutrient agar.

Regeneration from Roots

All the roots of *Radicula aquatica* are small and fibrous, and hence are of a type little suited for propagation. Repeated trials with pieces of roots in water and on moist paper in damp chambers showed

no regeneration at all. Finally, a number of pieces of roots were sterilized and cultured on sterile nutrient agar made up according to White's formula (15). The pieces of roots were segments 5 mm. long, cut from roots 1 mm. or less in diameter. No sign of development was observed for a long time, and daily examinations of the cultures gave way to infrequent ones. Because of this the exact time required for regeneration from these root segments is not known, but it is probably not less than sixty days nor more than ninety days.

The segments of roots did not branch, but tiny buds appeared in the middle portion of each of those which grew. Later shoots sprouted out from these buds, and new roots were formed on their bases. The small plants thus produced developed rapidly and formed normal plants.

Regeneration from Fruits

Buds and whole flowers were sterilized and cultured on nutrient agar. Sepals, petals, stamens, and pistils were cultured separately. Since the author had rooted petals of *Epilobium angustifolium* (9), it seemed probable to him that petals of *Radicula aquatica*, which come from a very regenerative species and which are about the same size as those of *Epilobium angustifolium*, could be rooted also. Apparently they could not. Sepals and stamens have never been rooted, and so their failure here was not unexpected. Several of the ovaries produced single roots from their cut basal ends.

Regeneration from Bud Meristems

The author has already reported the growth of bud meristems of Radicula in sterile culture (6). They were dissected from the buds and represented masses of meristematic tissue under 0.5 mm. in length. These meristems produced shoots on which roots were formed, and ultimately normal plants were developed from these small primordia. So far as the author has been able to discover, complete plants have not been grown from such minute masses of terminal meristem from any other species.

DISCUSSION

Considerable discussion of different phases of the reproductive activity of this species has been interlarded with the data and need not be repeated here. There are, in all probability, other plants

which have capacities for vegetative propagation and for regeneration equal to those of *Radicula aquatica*, but as yet none of them have been so completely explored. Little has been added here to our small knowledge of the factors which enable a plant to regenerate. But more progress is being made now on problems of growth and differentiation than has been attained in any previous period. As one of the most propagative and regenerative plants in existence *Radicula aquatica* should be a good subject for use in the study of these problems.

SUMMARY

1. Vegetative propagation of the species from leaves and stems is described.

2. Disbudded leaves produce new plants by bud regeneration. Sections of leaves, of a variety of shapes and sizes, are capable of regeneration.

3. Nodes deprived of buds are able to form new buds, and internodes in culture on nutrient agar are able to form both buds and roots.

4. Polarity is shown in developments from leaves and stems. Shoots on the upper stem strongly inhibit shoot development below them.

5. Indole acetic acid inhibits shoot growth on stems, but indole butyric acid produces a much stronger inhibition of outgrowths from buds.

6. Both indole acetic acid and indole butyric acid stimulate root formation on leaves and stems, but indole butyric acid shows the greater effect.

7. In culture on nutrient agar minute pieces of root are able to form new plants.

8. Meristems less than 0.5 mm. long have produced new plants on nutrient agar.

9. Ovaries dissected from mature flowers and placed on nutrient agar have formed roots on their basal ends.

10. *Radicula aquatica* is unusual in its ability to multiply by vegetative propagation and by regeneration.

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CLADONIA ALPICOLA IN NEW YORK STATE *

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THE Cladonia flora of most of the northeastern United States is well known through the collections of Tuckerman, Farlow, Robbins, Evans, and others. The alpine areas, however, have never been surveyed intensively by lichenists. The noteworthy discovery of a boreal Cladonia, here reported, on the summit of the highest mountain in New York State suggests that these mountain areas

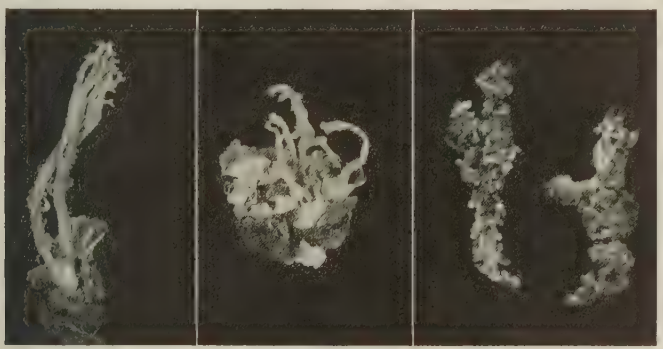

FIG. 1. A and B. Habit of the plant, × 1. C. Enlargement of the podetium, × 6. The peltate podetial squamules diagnostic for the species are distinct in the right-hand figure

offer a promising field for studies in the distribution of the northern Cladoniae.

Cladonia alpicola (Flot.) Vainio is a lichen that is readily identified, in its typical forms, by the large squamules of the primary thallus and by the peltate squamules on the podetium (Fig. 1). According to the literature (6), this lichen has been collected most frequently in the northern parts of Europe. It has also been noted from

* Paper from the Department of Forest Botany and Pathology, New York State College of Forestry, Syracuse, New York.

widely scattered stations in America: var. *foliosa* (Sommerf.) Vainio from Greenland and Newfoundland, by Wainio (5); and f. *Mougeotii* (Del.) Vainio, f. *minor* Vainio, and f. *Ehrhardtiana* Vainio from Alaska, by Merrill (3). Connecticut records of var. *karelica* Vainio (1) were later retracted, and a report of f. *minor* was qualified by several statements which indicated an uncertain classification of the collection (2). Nearing (4) includes this species in his lichen book, but does not say where it has been collected.

Typical plants of *Cladonia alpicola*, referable to var. *foliosa* f. *Mougeotii*, have been collected by the writer on Mount Marcy at elevations from 1,524 to 1,615 meters (5,000–5,300 feet) above sea level. They are rather uncommon, and reach their best development among moss on soil in moist protected cracks in rocks. The description given below is drawn from specimens found on Mount Marcy.

Squamules of the primary thallus usually persistent, thick or rather thick, of moderate size to large, 3–10 mm. in greatest dimension, simple or with broad lobes, esorediate, KOH , above light to more commonly dark greenish gray, impressed-areolate or, more rarely, the minute areoles separating and showing the white cortex within, below white except more or less brown at the base close to the substratum; podetia arising from the upper surface of the squamules, ascyphous, branched 1–4 times, usually 1.5 2.5 cm. in length, reaching an extreme length of 3.5 cm., cylindrical, about 1 2 mm. in diameter, the tips of the branches sterile or with small black sterile fruiting bodies; surface of the podetium at first similar to that of the primary squamules, very soon breaking up to form verrucae or, more often, peltate squamules, which may remain for a long time attached at the center, or fall off and expose the white or whitish, fibrous, sulcate chondroid layer beneath, or at times persist and elongate on one side to form squamules up to 1 mm. or more in length; fertile conidangia not found, nor apothecia.

Dr. E. W. Evans kindly examined a specimen and verified the species determination, adding that the plant should be referred to f. *Mougeotii*.

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THE DESMID GENUS MICRASTERIAS AGARDH IN SOUTHEASTERN UNITED STATES

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IT IS the intention of the authors in this and subsequent articles to add to the knowledge of desmid distribution and ecology, with special reference to southeastern United States. In an earlier paper (14) they pointed out that in the states bordering the Gulf of Mexico many of the algal habitats support desmid floras which are as luxuriant as those of the highly glaciated regions of North America. Their recent collections of fresh-water algae from Florida, Mississippi, and Louisiana make possible further comparisons of northern and subtropical desmid floras in this continent.

It is of interest to note that as these studies progress additional species previously reported only from New England or Newfoundland are found also in the subtropical Gulf region. The character of the desmid flora of the sandy soil ("yellow podzol") of the Gulf and the southeastern coastal plains of the Atlantic seaboard raises the old, interesting questions regarding the factors which determine the distribution of these plants. As data accumulate there is increasing evidence that these factors are specific and do not have a broad application to the family, or even to genera. Temperature and light periodicity seem to be important in limiting the distribution of some species, while water chemistry is a significant and determining ecological factor for others. *Micrasterias foliacea* Bail., for example, is found from subarctic to tropical regions, but its occurrence is so specifically related to water chemistry that the species can be used as an index organism for soft and highly acid water.

According to the authors' observations, the acidity of the water in which it grows may be predicted with assurance as lying between pH 5.8 and pH 6.4 (rarely as high as pH 6.8). *M. rotata* (Grev.) Ralfs on the other hand is not confined to an acid habitat, but is more ubiquitous, and not infrequently may appear in the microflora of habitats possessing a pH as high as 7.4. Some of the planktonic species, such as *M. radiata* (Grev.) Ralfs and its varieties, show a similar lack of restriction to acid habitats.

In their studies of desmid distribution the authors have observed that it is unusual for a habitat to have but one or two species of Micrasterias. Either there are a number of species or none, although in any case there may be an abundance of other desmids. This suggests a preference amounting to a generic selectivity on the part of Micrasterias species for a particular combination of chemiophysical factors. In subsequent studies this question will be examined in the hope of determining the limiting factors which are involved in this distribution.

Results of the present survey of the algal flora in the Gulf states support the observations of G. M. Smith, and of others who have found it necessary to take exception to the statements and theories of the Wests in England and Wittrock in Sweden regarding desmid distribution. It was the contention of these phycologists that desmid floras dominate only in water standing over or draining igneous rock. In general, desmid studies in New England support this idea, for here many algal habitats are underlain by ancient rock and the flora is predominantly of the desmid type. Rich desmid floras of a character somewhat similar to that of the rocky parts of New England appear, however, in the sand-plain lakes and bogs of southeastern New England, in the glacial drift of the upper Great Lakes region, and in the sandy soil of the Gulf Coast, none of these habitats being associated with igneous rock. The fact that desmids are abundant in respect to number of both species and individuals in water draining igneous rock as well as in sandy-soil substrates immediately suggests, of course, that there are similarities in the water chemistry of these two types of environments.

It is a well-known fact that desmid floras are best developed in water having a low pH (5.2–6.8). This is undoubtedly a correlation and not a causal relation. We know that desmids are abundant in water which contains a required optimum ratio of K–Na ions to

Ca–Mg. When the K–Na/Ca–Mg ratio is high, the water is of course relatively more alkaline. Calcium-rich lakes are, therefore, unfavorable for desmids, as are also soft-water lakes which are poor in nutrient ions.

The present paper deals with the genus Micrasterias, which includes some of the most beautiful plants in the Desmidiaceae. Cells of a number of species have a volume greater than that of almost any other desmid. Although the cell is usually very flat, having a thickness which may be only one sixth of the maximum dimension, the width is nearly always as great as the length (rarely greater) and the cell is approximately circular in outline.

The genus is unique among the Cosmarieae because of the definiteness with which it is separated from other members of the tribe. There are not, for example, intergrading forms, as there are between Cosmarium and Staurastrum and Euastrum or between Xanthidium and Arthrodesmus. Micrasterias is a highly derived genus in the desmid family, and one which is to be regarded, in so far as present evidence indicates, as terminating a line of evolutionary development.

With some exceptions, the taxonomic list below follows Krieger (8), who has done much to simplify the synonymy of Micrasterias species.

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List of Species

Micrasterias americana (Ehr.) Ralfs (f.) (Pl. I, Fig. 5). Length 138 μ, width 114–120 μ, isthmus 22.5 μ. Florida; Sorrento, Covington, Louisiana.

Micrasterias americana var. Hermanniana Reinsch. — Florida (Wolle, 1892).

Micrasterias arcuata Bail. Length 70–100 μ, width 65–80 μ, isthmus 14 μ. Swamp near New Smyrna Beach, Florida.

Micrasterias arcuata var. expansa (Bail.) Nordst. (Pl. I, Fig. 11;

Pl. VI, Figs. 2, 4). — Length 70 μ, width 67 μ, isthmus 11 μ. Sphagnum swamp near Pearl River, Louisiana; Florida.

Micrasterias arcuata var. gracilis W. & G. S. West (Pl. I, Fig. 15). — Length 75–85 μ, width 75–90 μ, isthmus 10–11 μ. Alabama (Brown, 1930); pond near Osteen, Florida.

Micrasterias arcuata var. **lata,** var. nov.[1] (Pl. I, Fig. 14; Pl. V, Fig. 2). — A very wide variety with both polar and lateral lobes greatly extended; apex broadly convex, slightly retuse in the median portion, extended into long, gradually tapering, slightly recurved arms which are tipped with a stout spine; lateral lobes disposed horizontally, very wide and stout at the base, tapering gradually to bifurcate tips, which slightly exceed the converging apical lobes; semicell with subparallel margins between the lateral and apical lobes; sinus widely open from broadly rounding angles; length 88–95.5 μ, width 133.2–155.4 μ, isthmus 14.4 μ. Lake Alfred near Winter Haven, Eustis Lake near Eustis, Florida.

This plant of unbalanced proportions suggests some of the varieties of *Micrasterias pinnatifida* (Kuetz.) Ralfs. Our specimens are all much wider than *M. pinnatifida,* and the tapering, slightly recurved arms of the polar lobe are similar to those of *M. arcuata.*

Micrasterias arcuata var. robusta Borge (Pl. VI, Fig. 3). — Length 55 μ, width 48 μ, isthmus 9.5 μ. Sphagnum bog 2 miles west of Pearl River, Louisiana.

Micrasterias conferta var. **glabra,** var. nov.[2] (text fig. 1). — A variety differing from the typical plant in its lack of spines within the dorsal margin of the polar lobe, and in having a mam-

[1] *Micrasterias arcuata* var. **lata,** var. nov. — Varietas latissima, lobis polaribus lateralibusque admodum extensis; apice late convexo, in media parte paululum retuso, in bracchia longa, gradatim attenuata, paululum recurvata, spinaque crassa praefixa, prolongato; lobis lateralibus horizontaliter productis, in basi latissimis crassissimisque, ad cacumina bifurcata, extra lobos apicales convergentes paululum excedentia gradatim attenuatis; semicellula margines subparallelos inter lobos laterales polaresque habente; sinu late aperto et ab angulis late rotundatis egrediente. Long. 88–95.5 μ, lat. 133.2–155.4 μ, lat. isth. 14.4 μ.

[2] *Micrasterias conferta* var. **glabra,** var. nov. — Varietas a typica planta differens inopia spinarum intra marginem dorsalem lobi polaris atque possessione protuberationis mammillatae in basi utriusque anguli lobi polaris; spina parva obtusa in apicibus lobulorum polarium; apicibus lobulorum lateralium autem processibus spinosis non praeditis velut in planta typica. Long. 97 μ, lat. 85 μ, lat. isth. 14.5 μ.

millate protuberance at the base of each angle of the polar lobe; a small blunt spine at the apices of the polar lobules; apices of lateral lobules without spiny processes, as in the typical plant; length 97 μ, width 85 μ, isthmus 14.5 μ. Rare in Devil's Swamp, 2 miles east of Westonia, Mississippi.

The polar lobe of this variety is very similar in shape and depth of incision to that of var. *hamata* Wolle, but its margins are quite smooth.

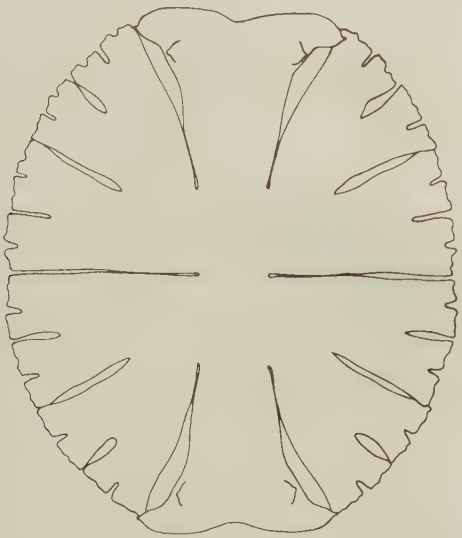

Fig. 1. *Micrasterias conferta* var. *glabra*, var. nov.

Micrasterias conferta var. hamata Wolle (Pl. I, Fig. 6). — Length 97 μ, width 82 μ, isthmus 13 μ. Florida; Picayune, Mississippi. Rare in the Gulf states region.

Micrasterias conferta var. hamata f. **spinosa,** f. nov.[3] (text fig. 2). — A form differing from the typical variety in having stout spines within the margins of the polar lobe and the inner

[3] *Micrasterias conferta* var. *hamata* f. **spinosa,** f. nov. — Forma a typica planta differens possessione spinarum crassarum intra margines lobi polaris marginesque interiores loborum superiorum lateralium; necnon spinis secundum margines basales semicellularum praedita. Long. 99 μ, lat. 86 μ, lat. isth. 13.5 μ.

margins of the upper lateral lobes; also with spines along the basal margins of the semicells; length 99 μ, width 86 μ, isthmus 13.5 μ. Rare in Devil's Swamp, 2 miles east of Westonia, Mississippi.

Micrasterias crenata De Bréb. — Florida (Bailey, 1851).

Micrasterias crux-melitensis (Ehr.) Hass. (Pl. V, Fig. 7). — Length 144 μ, width 104 μ, isthmus 18 μ. Everglades, Florida. Coll. Ruth Patrick. New for the region.

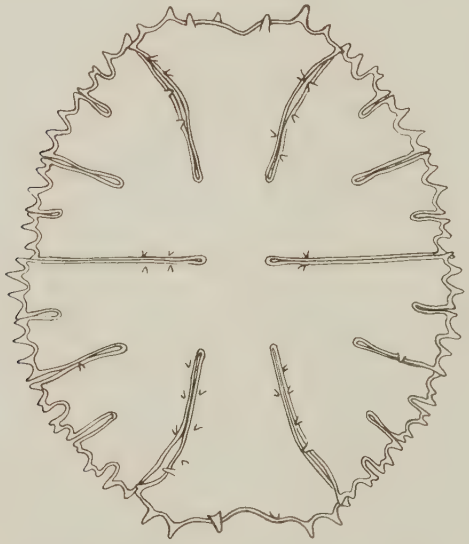

Fig. 2. *Micrasterias conferta* var. *hamata* f. *spinosa*, f. nov.

Micrasterias decemdentata (Naeg.) Arch. — Florida (Borge, 1909; Wolle, 1892).

Micrasterias denticulata De Bréb. (f.) (Pl. II, Fig. 1). — Length 155 μ, width 130 μ, isthmus 25 μ, width of polar lobe 57 μ. Alabama (Brown, 1930); Florida; Slidell, Louisiana; Grenada, Mississippi.

Micrasterias denticulata var. angulosa (Hantz.) W. & G. S. West. — Florida (Brown, 1930).

Micrasterias denticulata var. intermedia Nordst. (Pl. II, Fig. 9).

— Length 258 μ, width 225 μ, isthmus 32 μ. Sun, Louisiana. New for North America.

MICRASTERIAS DENTICULATA var. TAYLORII Krieg. (Pl. VI, Fig. 5). — Length 214 μ, width 190 μ, isthmus 24 μ. Near St. Tammany, Louisiana. Previously reported from Newfoundland.

MICRASTERIAS DEPAUPERATA var. **convexa,** var. nov.[4] (Pl. V, Figs. 3–4). — A variety with lateral margins convex, sloping from the apical incisions, which are not so deep as in the typical form; with a single blunt spine, instead of the usual bifurcate processes, on the upper lateral margins of the basal lobes, the lateral margin only slightly retuse between the spine and the lower angles, which are not produced but are furnished with two stout, curved teeth, as in the typical plant; sinus narrowly linear and closed from a sharply rounded angle throughout its entire length; length 130–140 μ, width 97–100 μ, isthmus 19.8–20.5 μ. Pond near Leesburg, Florida.

MICRASTERIAS DEPAUPERATA var. KITCHELII (Wolle) W. West (Pl. III, Fig. 5). — Length 124–127 μ, width 114–116 μ, isthmus 24–25 μ. Hickory, Louisiana. Rare. New for the region.

MICRASTERIAS FIMBRIATA Ralfs (f.) (Pl. IV, Fig. 5). — Length 237–244 μ, width 203–209 μ, isthmus 26–30 μ. Alabama (Brown, 1930); Florida; Covington, Bogalusa, Louisiana; Magnolia, Summit, Pascagoula, Mississippi.

This species shows a great deal of variation in the number and arrangement of the spines, which intergrade between those of the typical form and those of var. *spinosa* Biss. In the Mississippi plants a number of expressions appear, none of which agree with the typical plant because of the lack of spines within the apical margin of the polar lobe.

MICRASTERIAS FIMBRIATA var. SPINOSA Biss. (f.) (Pl. IV, Figs. 1–4, 9). — Length 206–237 μ, width 178–181 μ, isthmus 28.5 μ. Audubon Park, New Orleans, Louisiana; Pascagoula, Mississippi.

[4] *Micrasterias depauperata* var. **convexa,** var. nov. — Varietas marginibus lateralibus convexis, declivibus ab incisionibus apicalibus, quae non tam profundae quam in typica forma; unica spina obtusa in marginibus lateralibus superioribus loborum basalium vice solitorum processuum bifurcatorum; margine laterali vix retusa inter spinam angulosque inferiores, qui non producti sunt sed duobus dentibus crassis curvatis velut in planta typica praediti; sinu anguste lineari atque per totam longitudinem clauso et ab angulo abrupte rotundato egrediente. Long. 130–140 μ, lat. 97–100 μ, lat. isth. 19.8–20.5 μ.

Like the preceding form, this variety shows a modification in respect to the spines within the apical margin of the polar lobe.

MICRASTERIAS FLORIDENSIS var. **spinosa,** var. nov.[5] (f. *spinosa* Whelden, 1941, p. 269) (Pl. III, Fig. 10). — A variety similar to the typical plant except that there are three or four stout spines within the upper and lower margins of the lateral lobes and within the lateral margin of the polar lobe; length 172 μ, width 162 μ, isthmus 18 μ. Small lake in city park, Eustis, Florida.

MICRASTERIAS FOLIACEA Bail. (Pl. III, Figs. 6–7). — Length 136–170 μ, width 82–83.5 μ, isthmus 14.5–16 μ. Alabama (Brown, 1930); Hickory, Louisiana. New for the region.

MICRASTERIAS FURCATA Ralfs. — Florida (Bailey, 1851; Brown, 1930).

MICRASTERIAS FURCATA var. SIMPLEX Wolle. — Florida (Wolle, 1892).

MICRASTERIAS INCISA De Bréb. — Florida (Bailey, 1851).

MICRASTERIAS JENNERI Ralfs (Pl. II, Fig. 8). — Length 157–164 μ, width 112–115 μ, isthmus 26 μ. Picayune, Mississippi. New for the region.

MICRASTERIAS JENNERI var. SIMPLEX W. West (Pl. II, Figs. 5, 11; Pl. V, Fig. 9). — Length 82–164 μ, width 105–115 μ, isthmus 26 μ. Pearl River, Louisiana; Picayune, Mississippi. New for the region.

Both the typical form and var. *simplex* W. West are very rare in the Gulf region. Whenever this species appears it is accompanied by several others, in a highly acid habitat. Plate V, Figure 9, shows an expression which combines the marginal incisions of the typical plant and the smooth wall and polar lobe of var. *simplex* W. West.

MICRASTERIAS JOHNSONII W. & G. S. West. — Florida (W. and G. S. West, 1898).

MICRASTERIAS JOHNSONII var. RANOIDES (Salisb.) Krieg. (Pl. I, Fig. 18). — Length 198 μ, width 216 μ, isthmus 18 μ. Pond near Osteen, Florida.

This species and its variety *ranoides* (Salisb.) Krieg. have never been reported from anywhere except Florida.

[5] *Micrasterias floridensis* var. **spinosa,** var. nov. — Varietas typicae plantae similis praeterquam quod habet tres vel quattuor spinas crassas intra margines loborum lateralium superiores inferioresque atque intra margines lobi polaris laterales. Long. 172 μ, lat. 162 μ, isth. 18 μ.

MICRASTERIAS LATICEPS Nordst. — Florida; ditch near Baker, Slidell, Louisiana; small pond near Magnolia, lake near Dixie Springs, Summit, Mississippi.

MICRASTERIAS LATICEPS var. CRASSA Presc. (f.) (Pl. II, Figs. 2, 6). — Length 108–133 μ, width 114–141 μ, isthmus 23 μ. Lateral lobes higher than in the typical form; sinus narrower, closed for one half its length. Sorrento, Louisiana; Waveland, Mississippi. New for the region.

MICRASTERIAS MAHABULESHWARENSIS Hobs. (Pl. I, Figs. 9, 12; Pl. III, Fig. 12; Pl. VI, Fig. 6). — Length 125–160 μ, width 95–130 μ, isthmus 18–26 μ. Pond near Osteen, Florida; Sorrento, Lac des Allemands, Louisiana; lake near Dixie Springs, 4 miles north of Summit, Mississippi.

This plant intergrades with some of the expressions of *Micrasterias americana* (Ehr.) Ralfs to such an extent that it would seem logical to combine these two species.

MICRASTERIAS MAHABULESHWARENSIS var. DICHOTOMA G. M. Smith (Pl. I, Fig. 8; Pl. V, Fig. 10). — Length 133.2 μ, width 126 μ, isthmus 21 μ. Lake Minneola near Groveland, Florida. New for the region.

MICRASTERIAS MAHABULESHWARENSIS var. RINGENS (Bail.) Krieg. (Pl. V, Fig. 8). — Length 129 μ, width 111 μ, isthmus 21.6 μ. Royal Palm Park, Florida. Coll. Ruth Patrick.

MICRASTERIAS MURICATA (Bail.) Ralfs (Pl. I, Fig. 4). — Length 166 μ, width 106 μ, isthmus 19–20 μ. Generally distributed in many habitats throughout Florida, Louisiana, and Mississippi. Always found with other species of Micrasterias. New for the region.

MICRASTERIAS NOVAE-TERRAE (Cushm.) Krieg. (Pl. I, Fig. 10). — Length 128–135 μ, width 98–110 μ, isthmus 11 μ. Pond near Osteen, Florida. New for the region.

MICRASTERIAS OSCITANS Ralfs (Pl. II, Fig. 14). — Length 150 μ, width 118 μ, isthmus 23 μ. Florida; Picayune, Mississippi.

MICRASTERIAS OSCITANS var. MUCRONATA (Dix) Wille (f.) (Pl. II, Fig. 10). — Length 137 μ, width 112 μ, isthmus 30 μ. Pearl River, Louisiana. New for the region.

MICRASTERIAS OSCITANS var. MUCRONATA (Dix) Wille (f.) (Pl. II, Fig. 13). — Length 128 μ, width 120 μ, isthmus 28 μ. Pearl River, Louisiana.

This form is intermediate between the typical plant and var. *mucronata* (Dix) Wille. The polar lobe is similar to that of the species, but the high dorsal margins of the lateral lobes, with a tendency to have mucrones, are characteristics of the variety.

Micrasterias papillifera De Bréb. — Florida (Bailey, 1851; Wood, 1874).

Micrasterias papillifera var. speciosa (Wolle) Krieg. (Pl. V, Fig. 11). — Length 112–120 μ, width 108 μ, isthmus 14.5 μ. Sphagnum swamp near Pearl River, Louisiana; Florida.

Micrasterias pinnatifida (Kuetz.) Ralfs (Pl. I, Figs. 13, 17). — Length 62 μ, width 72 μ, isthmus 15 μ. In ponds and ditches throughout Florida, Louisiana, and Mississippi.

This species shows considerable variation, but the varieties do not seem to appear in the same habitat, which suggests that the plant is very responsive to varying chemiophysical environmental conditions.

Micrasterias pinnatifida var. quadrata Bail. — Florida (Bailey, 1851).

Micrasterias piquata Salisb. (Pl. II, Fig. 17). — Length 106–111 μ, width 83–96 μ, isthmus 17–19 μ. Pond near Bay St. Louis, ditch near Magnolia, Mississippi; Florida.

Micrasterias piquata f. **picayunensis,** f. nov.[6] (Pl. I, Fig. 3). — A form larger than the typical one; polar lobe strongly convex and not at all emarginate, as it is in the species, and higher, separated from the lateral lobes by a wider incision, the dorsal margins of the lateral lobes being almost horizontal; sinus usually more widely open outwardly; length 128–151 μ, width 105–123 μ, isthmus 25–30 μ. Covington, Hickory, Louisiana; Picayune, Mississippi.

Micrasterias radiata Hass. (Pl. I, Fig. 16; Pl. V, Fig. 1). — Length 95 μ, width 162 μ, isthmus 25 μ. Widely distributed and common in collections from Florida, Louisiana, and Mississippi.

Plate I, Figure 16, shows one of the many forms of this species. Plate V, Figure 1, illustrates an abnormal cell which possesses a

[6] *Micrasterias piquata* f. **picayunensis,** f. nov. — Forma maior quam typica; lobo polari valde convexo, haud emarginato velut in specie; lobo polari altiore et a lobis lateralibus incisione latiore separato, marginibus dorsalibus loborum lateralium paene horizontalibus; sinu exteriore in parte plerumque latius aperto. Long. 128–151 μ, lat. 105–123 μ, lat. isth. 25–30 μ.

semicell of the typical plant and one similar to those of var. *gracillima* G. M. Smith.

MICRASTERIAS RADIATA var. DICHOTOMA (Wolle) Cushm. (Pl. III, Fig. 1). — Length 159–165 μ, width 152–165 μ, isthmus 20.5 μ. Slidell, Louisiana. Very abundant in one collection. New for the region.

MICRASTERIAS RADIATA var. GRACILLIMA G. M. Smith (Pl. III, Fig. 3). — Length 145–160 μ, width 135–148 μ, isthmus 16 μ. Hickory, Lacomb, Louisiana; Pearlington, Summit, Mississippi. New for the region.

MICRASTERIAS RADIOSA Ralfs (Pl. III, Fig. 4; Pl. IV, Figs. 13-14). — Length 196 μ, width 189 μ, isthmus 20 μ. Alabama; Titusville, Florida; Goodbee, Louisiana; Summit, Magnolia, Pearlington, Mississippi.

MICRASTERIAS RADIOSA var. ACULEATA Krieg. (f.) (Pl. VI, Fig. 7). — Length 235 μ, width 234 μ, isthmus 18 μ. Magnolia, Mississippi. New for North America.

This plant has some characteristics of var. *aculeata* Krieg., but lacks spines (as does the typical form) except at the apex of the polar lobe, which is furnished with two pairs of aculei similar to those of the variety. We have not seen enough specimens to determine whether this is a distinct and constant expression.

MICRASTERIAS RADIOSA var. ELEGANTIOR G. S. West (f.) (Pl. III, Fig. 9; Pl. IV, Figs. 11–12). — Length 231–241 μ, width 222–238 μ, isthmus 24–25 μ. Oakhill, Florida; Sun, Louisiana; Magnolia, Summit, Mississippi.

This plant has a great many varieties of expression in our collections. In Plate IV, Figures 11–12, are shown some plants which have polar lobes like those of var. *elegantior* G. S. West, but which do not have spines within the lateral margins of the lobes.

MICRASTERIAS RADIOSA var. **extensa,** var. nov.[7] (Pl. IV, Figs. 7–8,

[7] *Micrasterias radiosa* var. **extensa, var. nov.** — Varietas lobis polaribus ultra lobos laterales paululum extensis; marginibus lateralibus lobi polaris $\frac{3}{4}$ longitudinis a basi subparallelis deinde abrupte divergentibus necnon apicem latum margine dorsali concavo efficientibus; angulis lateralibus lobi polaris in spinam brevem productis, et spinam crassam extrorsus divergentem sitamque admodum intra marginem angulorum lateralium eius habentibus; margine ventrali semicellulae atque marginibus lobulorum undulatis; sinu in exteriore parte late aperto,

10). — A variety with polar lobes somewhat extended beyond the lateral lobes, the lateral margins of the polar lobes subparallel for three fourths of their length from the base and then diverging abruptly to form a broad apex, which has a concave dorsal margin; the lateral angles of the polar lobe extended into a short spine, with a stout, outwardly diverging spine just within their margin; ventral margin of the semicell and margins of the lobules undulate; sinus widely open outwardly, gradually narrowing to a rounded angle; basal lobules extended much beyond the length of the other lobes and generally terminating in a single process rather than a bifurcate one; a row of spines usually present within the ventral margins of the semicell, along the lateral margins of the polar lobe, and along the upper margins of the lateral lobes; length 200 μ, width 272 μ, isthmus 20 μ. Pearl River, Louisiana.

Micrasterias radiosa var. ornata Nordst. (Pl. III, Fig. 8). — Length 143 231 μ, width 136–222 μ, isthmus 15.5–24 μ. Lumberton, Magnolia, Summit, Mississippi. New for the region.

Micrasterias rotata (Grev.) Ralfs (Pl. III, Fig. 11; Pl. IV, Fig. 6). Length 253 297 μ, width 237–261 μ, isthmus 32 μ. Magnolia, Summit, Mississippi.

This differs from the usual form in the absence of spines and in the shallower denticulations of the lobules.

Micrasterias suboblonga var. **maxima,** var. nov.[8] (Pl. I, Fig. 7). — A variety larger than the typical one; cell oblong; the polar lobe broadly convex at the apex, margin of the lateral lobes convex to the basal angles, which are rounded and tipped with a blunt spinelike protuberance; sinus narrowly linear from a slightly rounded angle; length 143 μ, width 102 μ, isthmus 33 μ. Picayune, Mississippi.

ad angulum rotundatum gradatim attenuato; lobulis basalibus multo longius aliis lobis productis, et plerumque in extrema parte processum unicum potius quam bifurcatum efficientibus; plerumque ordine spinarum intra margines ventrales semicellulae et secundum margines laterales lobi polaris loborumque lateralium superiorum. Long. 200 , latμ. 272 μ, lat. isth. 20 μ.

[8] *Micrasterias suboblonga* var. **maxima,** var. nov. — Varietas maior quam planta typica; cellula oblonga; lobo polari in apice late convexo, margine loborum lateralium convexo, angulis basalibus rotundatis praefixisque protuberatione obtusa spiniformi; sinu anguste lineari et ab angulo paululum rotundato egrediente. Long. 143 μ, lat. 102 μ, lat. isth. 33 μ.

This plant is similar to the much smaller var. *australis* Krieg. and should be compared with it.

Micrasterias tetraptera var. **protuberans,** var. nov.[9] (Pl. V, Figs. 5–6). — A variety larger than the typical one; polar lobe broader and strongly bilobed, the apical margin concave and the lateral angles furnished with three short spines along the dorsal margin; membrane spiny within the margins of the polar lobe and the upper lateral lobes and along the ventral margin of the semicell, a prominent median swelling at the base of the semicell; sinus narrowly linear throughout its entire length; length 138–146 μ, width 135–138 μ, isthmus 18.5–20 μ. Pond near Leesburg, Florida.

This variety is similar, in general, to var. *Taylorii* Krieg., especially in the shape of the polar lobe, but var. *Taylorii* has no spines and there are no protuberances at the base of the semicells.

Micrasterias tetraptera var. Taylorii Krieg. (f.) (Pl. VI, Fig. 1). — Length 75.6–79 μ, width 60–68 μ, isthmus 12–14.5 μ. Ricefields near Carville, Louisiana. New for the region.

Micrasterias Torreyi Bail. — Length 250–410 μ, width 450 μ, isthmus 27 μ. Pond near Osteen, Florida.

Micrasterias Torreyi var. Nordstedtiana (Hier.) Schm. (f.) (Pl. III, Fig. 2). — Length 325 μ, width 285–290 μ, isthmus 28.8 μ. Pond near Osteen, Florida. New for North America.

In our specimens the apices of the lobules have bifurcations with short rounded tips.

Micrasterias triangularis Wolle (Pl. II, Figs. 15–16). — Length 216–232 μ, width 108–184 μ, isthmus 30 μ. Picayune, Mississippi. New for the region.

Micrasterias truncata (Corda) De Bréb. (Pl. II, Fig. 7). — Length 125 μ, width 112 μ, isthmus 20 μ. Alabama (Brown, 1930); widely distributed in Florida, Louisiana, and Mississippi.

This plant shows numerous variations, many of which have been named. It appears to be one of the desmid species which is

[9] *Micrasterias tetraptera* var. **protuberans,** var. nov. — Varietas maior quam planta typica; lobo polari latiore atque valde bilobato, margine apicali concavo, angulis lateralibus tribus spinis brevibus secundum marginem dorsalem praeditis; membrana spinosa intra margines lobi polaris loborumque lateralium superiorum et secundum marginem ventralem semicellulae, inflatione prominente media ad basim semicellulae; sinu anguste lineari per totam longitudinem. Long. 138–146 μ, lat. 135–138 μ, lat. isth. 18.5–20 μ.

able to adapt itself to a great variety of limnological factors. It is found in habitats ranging from a pH of 6.2 to one of 7.4.

Micrasterias truncata var. **convexa,** var. nov.[10] (Pl. II, Fig. 3). — A variety somewhat smaller than the typical one; cells subcircular to oblong in outline, the poles broadly convex or sometimes flattened and slightly retuse in the median portion; sinus narrowly linear and closed throughout its entire length; semicells three-lobed, the lateral incisions very slight, being only one fourth the depth of the polar incisions, which are narrow and almost horizontal; the lateral lobules furnished with three toothlike projections at the angles; lateral angles of the polar lobe broadly rounded and relatively much deeper than in the other varieties, furnished with three prominent toothlike projections on the lateral and dorsal margins; length 57–136 μ, width 57–112 μ, isthmus 26 μ. Bonfouca, Louisiana; Picayune, Mississippi.

The recurved margins of the polar lobe and the height of this lobe from the ventral to the dorsal margin separate this plant from the other described varieties.

Micrasterias truncata var. pusilla f. **cuneata,** f. nov.[11] (Pl. II, Fig. 12). — A circular form with a broadly rounded apex that is produced laterally and tipped with a single stout spine which is either horizontal or curved upward; polar lobe cuneate, incisions below the polar lobe moderately wide from broadly rounded angles, the ventral margins of the polar lobe and the

[10] *Micrasterias truncata* var. **convexa,** var. nov. — Varietas aliquantulum minor quam planta typica; cellulis subrotundis ad oblongas variantibus, polis late convexis aut interdum complanatis atque in media portione paululum retusis; sinu anguste lineari perque totam longitudinem clauso; semicellulis 3-lobatis, incisionibus lateralibus admodum brevibus, solum ¼ longitudinis incisionum polarium, his angustis atque paene horizontalibus; lobulis lateralibus ad angulos tribus projectionibus dentiformibus praeditis; angulis lateralibus lobi polaris late rotundatis atque relative multo profundioribus quam in varietatibus aliis, in marginibus lateralibus dorsalibusque projectionibus prominentibus dentiformibus praeditis. Long. 57–136 μ, lat. 57–112 μ, lat. isth. 26 μ.

[11] *Micrasterias truncata* var. *pusilla* f. **cuneata,** f. nov. — Forma rotunda, apice late rotundato qui lateraliter productus est atque una spina crassa aut horizontali aut sursum curvata praefixus; lobo polari cuneato, incisionibus infra lobum polarem paulum latis et ab angulis late rotundatis egredientibus, marginibus ventralibus lobi polaris atque marginibus superioribus loborum lateralium undulatis subparallelisque; semicellula 5-lobata, duobus lobis lateralibus in duos lobulos, in duobus angulis crassa spina praefixos, divisis; sinu anguste lineari atque clauso, triente exteriore longitudinis excepto, qua in parte paululum apertus est. Long. 56–58 μ, lat. 57 μ, lat. isth. 10 μ.

upper margins of the lateral lobes undulate and subparallel; semicell five-lobed, the two lateral lobes divided into two lobules, which are tipped at each of their two angles with a stout spine; sinus narrowly linear and closed except in the outer third of its length, where it is slightly opened; length 56–58 μ, width 57 μ, isthmus 10 μ. Everglades, Florida; Slidell, Louisiana.

MICRASTERIAS TRUNCATA var. QUADRATA Bulnh. (Pl. I, Fig. 1). — Length 125 μ, width 112 μ, isthmus 22 μ. Picayune, Mississippi. New for North America.

MICRASTERIAS TRUNCATA var. SEMIRADIATA (Naeg.) Cleve (Pl. II, Fig. 4). — Length 85 μ, width 98 μ, isthmus 49 μ. Ditch near Atchafalaya Spillway, Louisiana. New for the region.

MICRASTERIAS TRUNCATA var. TRIDENTATA Krieg. (f.) (Pl. I, Fig. 2). — Length 130 μ, width 112 μ, isthmus 26 μ. Picayune, Mississippi; Montreal, Canada (Irénee-Marie, 1938).

This variety seems to agree with var. *tridentata* Krieg. except that the angles of the polar lobe are not bifurcate, as in the originally described plant.

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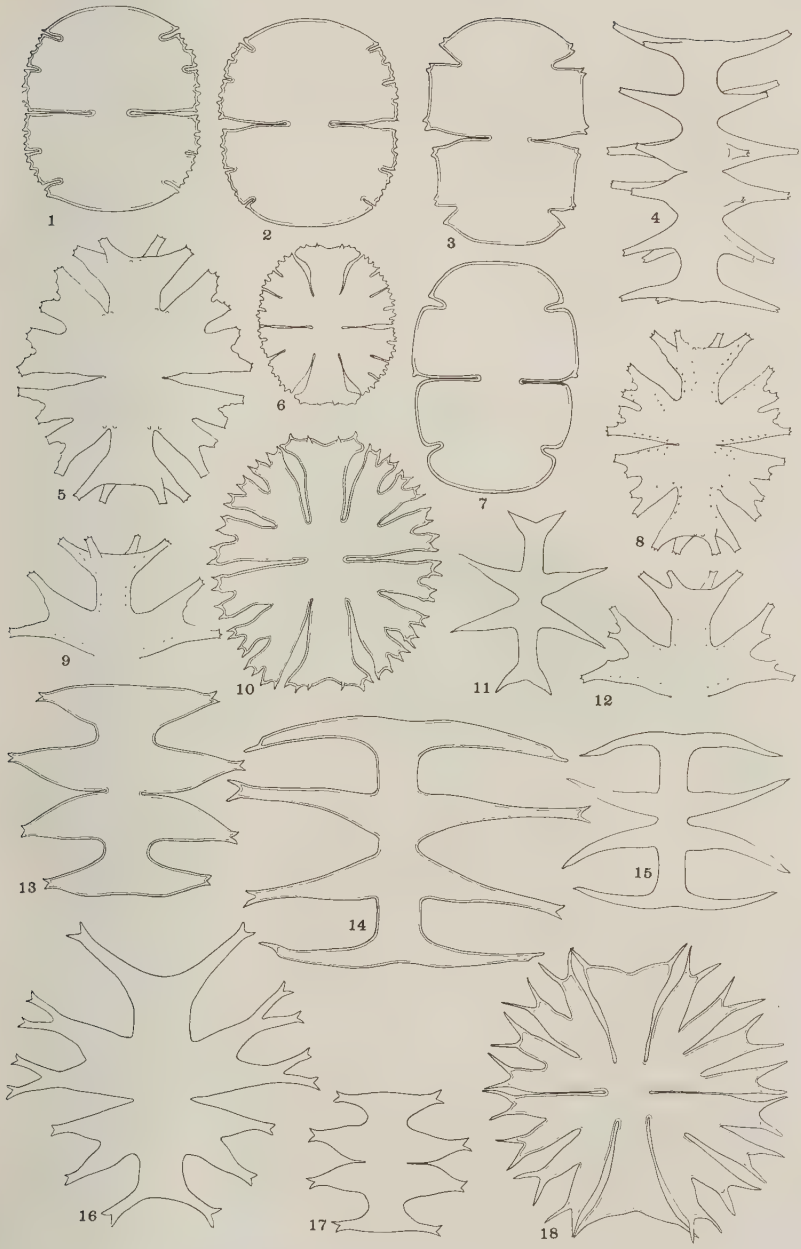
PLATES I-VI

EXPLANATION OF PLATE I

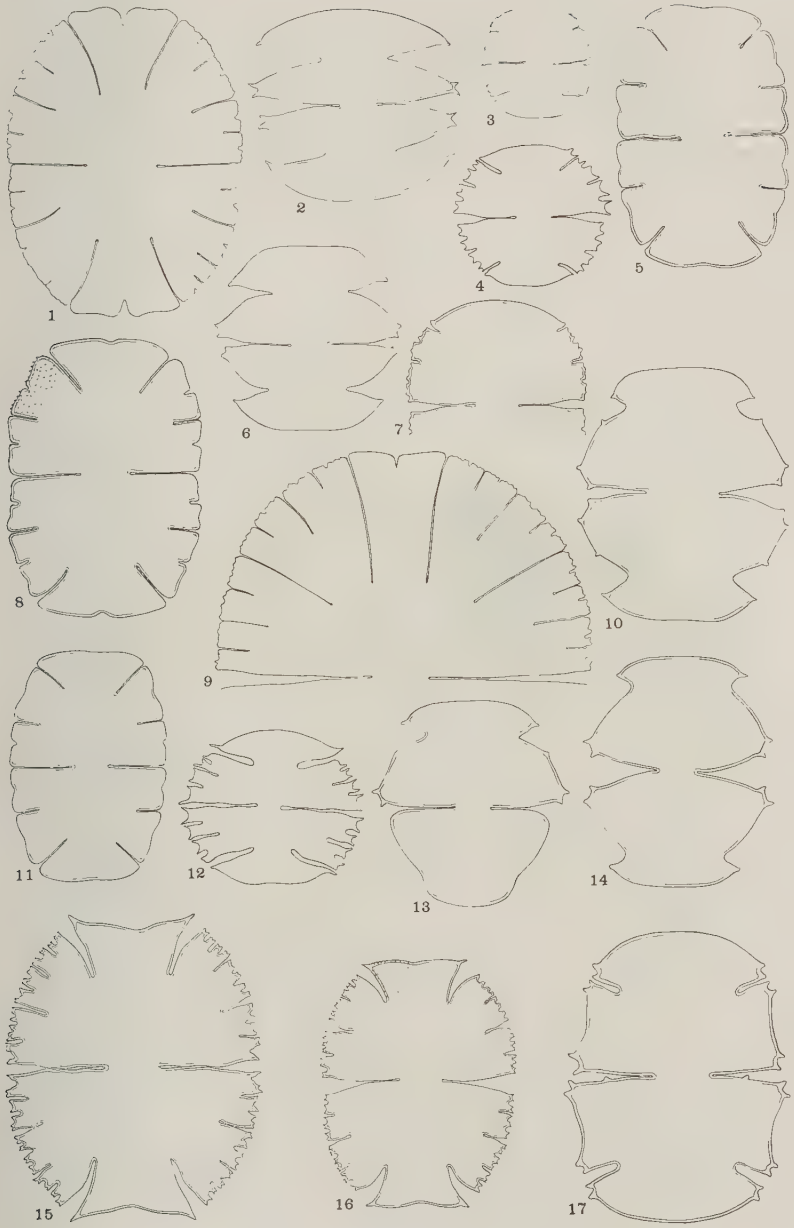
1. Micrasterias truncata var. quadrata Bulnh.
2. M. truncata var. tridentata Krieg., f.
3. M. piquata f. picayunensis, f. nov.
4. M. muricata (Bail.) Ralfs
5. M. americana (Ehr.) Ralfs, f.
6. M. conferta var. hamata Wolle
7. M. suboblonga var. maxima, var. nov.
8. M. mahabuleshwarensis var. dichotoma G. M. Smith
9. M. mahabuleshwarensis Hobs.
10. M. novae-terrae (Cushm.) Krieg.
11. M. arcuata var. expansa (Bail.) Nordst.
12. M. mahabuleshwarensis Hobs.
13. M. pinnatifida (Kuetz.) Ralfs
14. M. arcuata var. lata, var. nov.
15. M. arcuata var. gracilis W. & G. S. West
16. M. radiata Hass., f.
17. M. pinnatifida (Kuetz.) Ralfs
18. M. Johnsonii var. ranoides (Salisb.) Krieg.



Desmids from the southeastern United States

EXPLANATION OF PLATE II

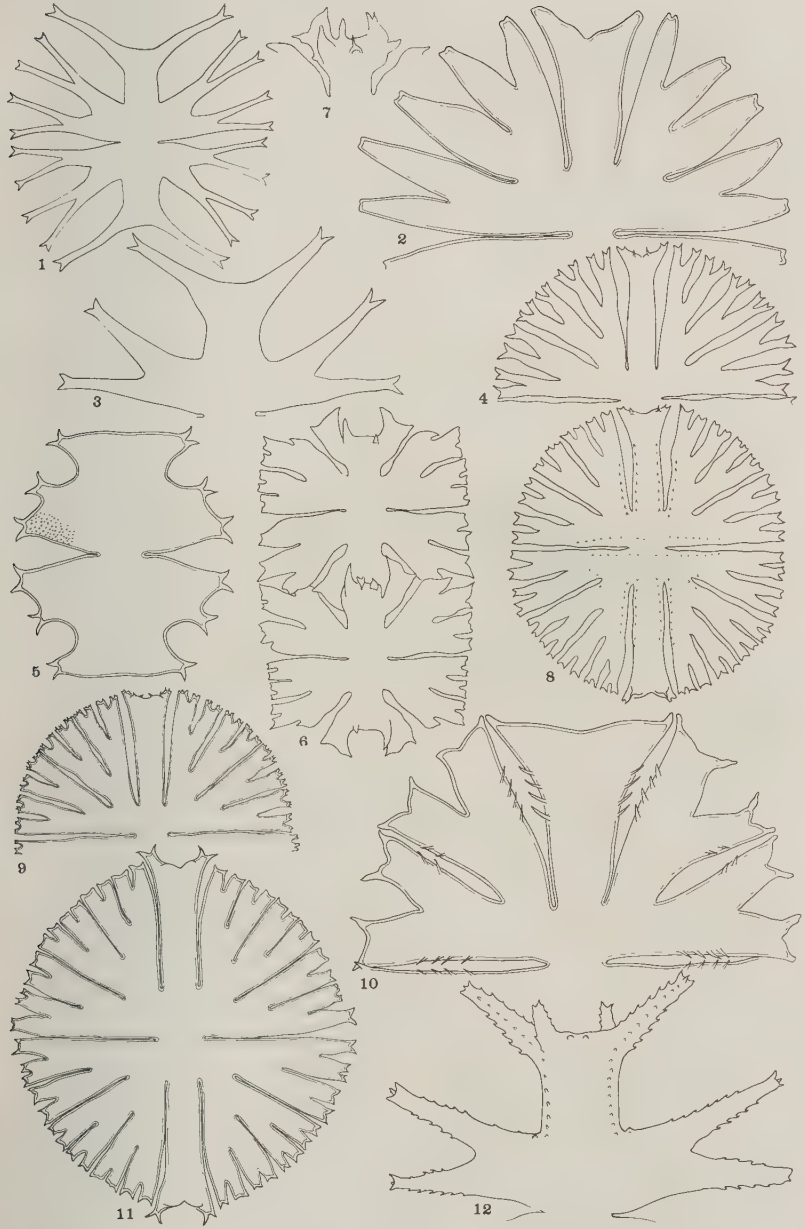
1. Micrasterias denticulata De Bréb., f.
2. M. laticeps var. crassa Presc., f.
3. M. truncata var. convexa, var. nov.
4. M. truncata var. semiradiata (Naeg.) Cleve
5. M. Jenneri var. simplex W. West
6. M. laticeps var. crassa Presc., f.
7. M. truncata (Corda) De Bréb.
8. M. Jenneri Ralfs
9. M. denticulata var. intermedia Nordst.
10. M. oscitans var. mucronata (Dix) Wille, f.
11. M. Jenneri var. simplex W. West
12. M. truncata var. pusilla f. cuneata, f. nov.
13. M. oscitans var. mucronata (Dix) Wille, f.
14. M. oscitans Ralfs
15. 16. M. triangularis Wolle
17. M. piquata Salisb.



Desmids from the southeastern United States

EXPLANATION OF PLATE III

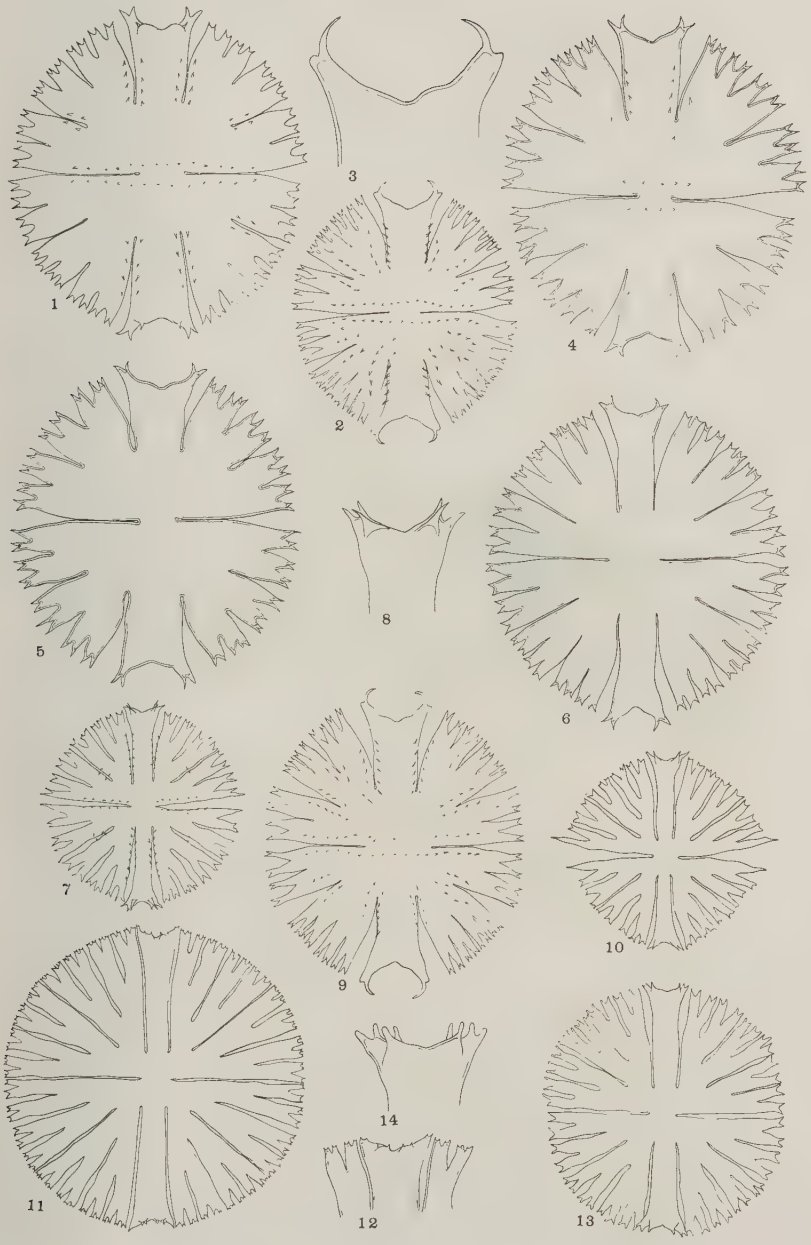
1. Micrasterias radiata var. dichotoma (Wolle) Cushm.
2. M. Torreyi var. Nordstedtiana (Hier.) Schm., f.
3. M. radiata var. gracillima G. M. Smith
4. M. radiosa Ralfs
5. M. depauperata var. Kitchelii (Wolle) W. West
6. M. foliacea Bail.
7. M. foliacea Bail., detail of apical region, polar lobe
8. M. radiosa var. ornata Nordst.
9. M. radiosa var. elegantior G. S. West, f.
10. M. floridensis var. spinosa, var. nov.
11. M. rotata (Grev.) Ralfs
12. M. mahabuleshwarensis Hobs.



Desmids from the southeastern United States

EXPLANATION OF PLATE IV

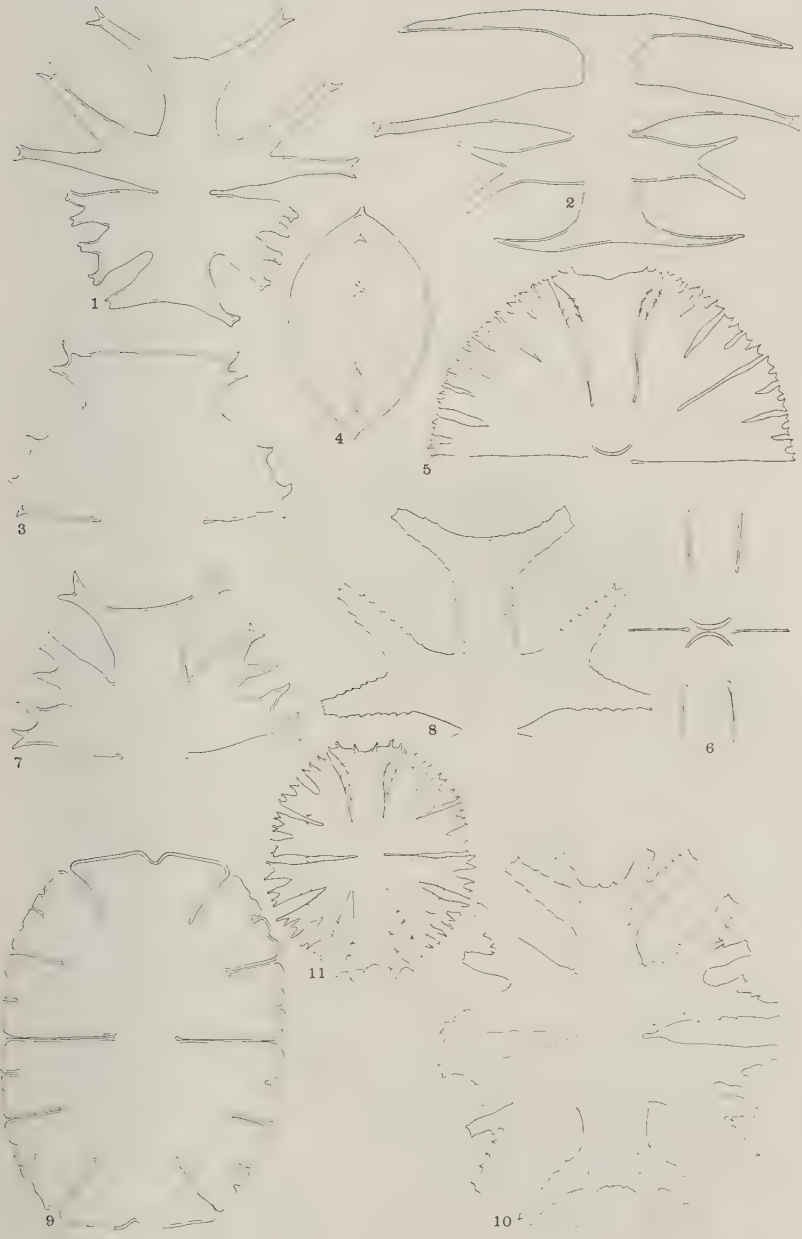
1 2. Micrasterias fimbriata var. spinosa Biss.
3. M. fimbriata var. spinosa Biss., f., detail polar lobe
4. M. fimbriata var. spinosa Biss., f.
5. M. fimbriata Ralfs, f.
6. M. rotata (Grev.) Ralfs
7. M. radiosa var. extensa, var. nov.
8. M. radiosa var. extensa, var. nov., detail polar lobe
9. M. fimbriata var. spinosa Biss., f.
10. M. radiosa var. extensa, var. nov.
11. M. radiosa var. elegantior G. S. West, f.
12. M. radiosa var. elegantior G. S. West, f., detail polar lobe
13. M. radiosa Ralfs
14. M. radiosa Ralfs, detail polar lobe



Desmids from the southeastern United States

EXPLANATION OF PLATE V

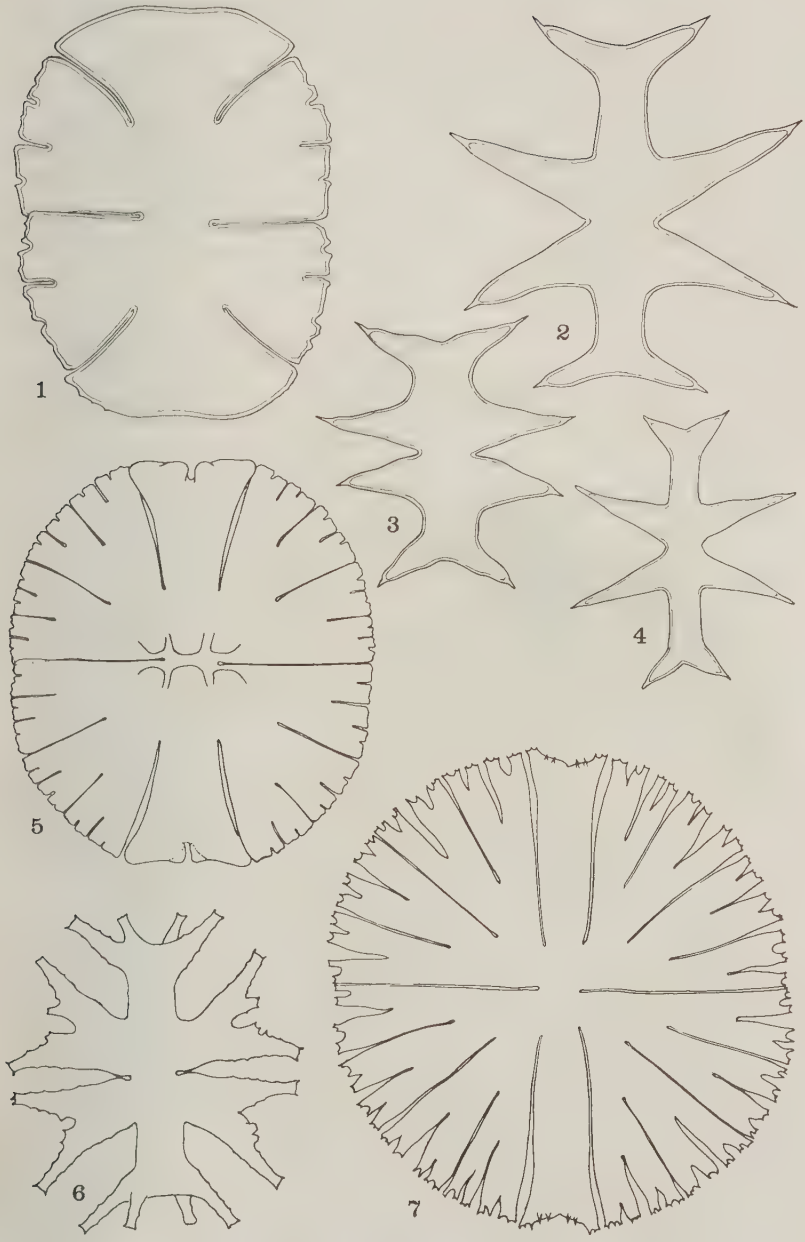
1. Micrasterias radiata Hass., abnormal semicell approaching var. pseudocrux Grönbl.
2. M. arcuata var. lata, var. nov.
3 4. M. depauperata var. convexa, var. nov.
5. M. tetraptera var. protuberans, var. nov.
6. M. tetraptera var. protuberans, var. nov., detail mid-region
7. M. crux-melitensis (Ehr.) Hass.
8. M. mahabuleshwarensis var. ringens (Bail.) Krieg.
9. M. Jenneri var. simplex W. West
10. M. mahabuleshwarensis var. dichotoma G. M. Smith
11. M. papillifera var. speciosa (Wolle) Krieg.



Desmids from the southeastern United States

EXPLANATION OF PLATE VI

1. Micrasterias tetraptera var. Taylorii Krieg., f.
2. M. arcuata var. expansa (Bail.) Nordst.
3. M. arcuata var. robusta Borge
4. M. arcuata var. expansa (Bail.) Nordst.
5. M. denticulata var. Taylorii Krieg.
6. M. mahabuleshwarensis Hobs., f.
7. M. radiosa var. aculeata Krieg., f.



Desmids from the southeastern United States

A MONOGRAPH ON THE GENUS LEUCOPAXILLUS BOURSIER *

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IN THE Friesian classification of the agarics the genera Tricholoma and Clitocybe are separated by the manner in which the gills are attached to the stipe. In the former they are characterized as sinuate or emarginate, whereas in the latter they are described as broadly adnate or decurrent. At first glance this appears to be a fairly sharp separation, but in practice it has not been so useful as one might expect it to be. In fact, on the basis of this distinction certain forms so closely related that we have included them as varieties within a species in the following account have previously been grouped in different genera. A study of the specimens prepared by Karsten, Peck, Kauffman, and others has further demonstrated to us that previous investigators often disagreed concerning the generic disposition of a given species. The present monograph is designed to clear up some of the confusion noted above. By segregating certain of the border-line species in the genus Leucopaxillus not only does the classical distinction between Clitocybe and Tricholoma become much more precise, but a number of obviously very closely related species are brought together in an arrangement that is both practical and natural. In spite of the emphasis given to chemical and anatomical characters in the definition of the genus that follows, experience has proved that it is easy for a skilled collector to recognize the Leucopaxilli in the field by their macroscopic characters. Surely no critical students of agarics, not even those who are averse

* Contribution from the Laboratory of Cryptogamic Botany and the Farlow Herbarium No. 211, Harvard University, and the Herbarium of the University of Michigan.

to changes in the system of classification used in gill fungi, will deny that in this instance the study of the fungi grouped here has been made much simpler and much more logical than it was under the Friesian system.

The diagnostic characters of the genus can be briefly summarized as follows: Pileus generally rather fleshy and unpolished, the surface more or less fibrillose under a lens, the margin usually inrolled, tomentose at least when young, and frequently ribbed or grooved; gills close to crowded and variable in the manner of their attachment — from somewhat sinuate to distinctly decurrent; stipe fleshy to fibrous-fleshy and quite firm; spores white in mass, either *smooth* or *verrucose* and *amyloid;* pleurocystidia absent; clamp connections present.

Boursier (1) established the genus for *Clitocybe paradoxa* C. & D. and *Tricholoma pseudoacerbum* C. & D. Previously the species now arranged in Leucopaxillus have been distributed in Clitocybe (*C. albissima, paradoxa, piceina, subhirta, amara, pulcherrima, rhodoleuca, candida*) and Tricholoma (*T. laterarium, pseudoacerbum, tricolor, lentum*) as well as in genera like Pleurotus (*P. nauseosodulcis*) and Paxillus (*P. giganteus*).

In 1887 Patouillard (8) segregated the rough-spored species of Clitocybe in the genus Lepista. In 1887, however, and again in 1900 he (9) defined Lepista as including only the species of the section Inversae of Clitocybe (*C. gilva, C. inversa,* and others believed to be rough-spored). Since *C. gilva* was the first species mentioned, it should be regarded as the type of the genus Lepista. Since its spores are not amyloid, the name "Lepista" cannot be applied to the species here placed in Leucopaxillus, even though at least one species of the latter (*L. amarus*) was later placed in Lepista by Patouillard. On this basis the name "Lepista," in the sense of Patouillard, does not have priority over the name "Leucopaxillus," but instead becomes a synonym of Clitocybe.

In 1924 Maire (7) referred the Leucopaxilli to Lepista, and recently Konrad and Maublanc (4, Vol. VI) reduced Leucopaxillus to the rank of a subgenus of Lepista. Maire (6), however, abandoned his earlier view in 1934, when, with Kühner, he studied the iodine reactions of the spore walls of the white-spored genera of the Agaricineae. Kühner (5) himself had adopted Leucopaxillus as an autonomous genus as early as 1926. In 1934 Kühner and Maire (6) also

created a new genus, Aspropaxillus, for the species with amyloid but smooth spores. Since these species had essentially the same characters in other respects, Singer (11) emended the genus Leucopaxillus to include *Clitocybe candida*, *C. gigantea* (= *Paxillus giganteus*), and *C. lepistoides*. He also pointed out that the presence of clamp connections formed an additional distinguishing character of the genus.

When we began the study presented in this monograph the following species were already known to belong in Leucopaxillus: *Clitocybe albissima* Peck, *C. amara* Fr., *C. candida* Bres., *C. paradoxa* C. & D., *C. piceina* Pk., *C. rhodoleuca* (Rom.) Sacc., *Lepista barbara* Maire, *Paxillus giganteus* Fr., *Tricholoma pseudoacerbum* C. & D., and *T. tricolor* Peck. We are adding *C. albiformis* Murrill, *C. pulcherrima* Peck, *C. stipitata* Murrill, *C. subhirta* Peck, *Melanoleuca bicolor* Murrill, *M. oreades* Murrill, *M. roseibrunnea* Murrill, *Pleurotus nauseosodulcis* (Karst.) Sacc., *Tricholoma laterarium* Peck, *T. lentum* (Romell) Sacc., *T. brasiliense* Rick, and *Leucopaxillus gracillimus* S. & S. There has been no previous attempt to study the species of Leucopaxillus from the flora of a particular region or to monograph them.

We wish to express our appreciation to Dr. H. D. House, state botanist of New York, for the privilege of studying the collections of Dr. Charles H. Peck. These collections are preserved at the New York State Museum, Albany, New York. We are also indebted to Dr. F. J. Seaver, of the New York Botanical Garden, for access to the collections of Dr. W. A. Murrill; to Dr. E. B. Mains for the use of Kauffman's notes and the collections in the University of Michigan Herbarium; and to Dr. David H. Linder for access to the various collections deposited in the Farlow Herbarium of Harvard University.

For aid in carrying out part of the field work we gratefully acknowledge the courtesies extended to the senior author by Dr. Ralph T. King, director of the Roosevelt Wildlife Forest Experiment Station, Huntington Forest, Newcomb, New York, and grants made to the junior author by the Horace H. Rackham School of Graduate Studies of the University of Michigan. These grants rendered possible the field work along the Pacific coast that contributed in a large measure to the completeness of this investigation, as well as expeditions to the Great Smoky Mountains National Parks.

DEFINITION AND LIMITS OF THE GENUS

The genus Leucopaxillus is determined by the following characters: The spores are amyloid, pure white in prints on white paper, hyaline under the microscope, small to medium-sized ($< 10\ \mu$), ellipsoid to ovoid or subglobose, without a smooth suprahilar spot and either smooth or roughened (not truly echinulate). The amyloid character of the spore wall must be determined by examining the spores under a microscope in daylight. The preparation is first treated with ammonia for a few seconds or minutes. The ammonia is then extracted and replaced by Melzer's reagent (iodide of potassium 1.5 gr.; iodine 0.5 gr.; distilled water 20.0 gr.; chloral hydrate 20.0 gr.). If the spore walls turn slate violet or dark violet they are amyloid. Nonamyloid spores stay hyaline or become yellowish, and so-called pseudoamyloid spores become intensely reddish brown. Slightly amyloid spores like those of *Leucopaxillus candidus*, *L. giganteus*, and *L. lepistoides* are kept in the medium for a short time (about 15 minutes). The coloration in these species is observed more clearly wherever the spores are in groups.

The hyphae bear numerous easily demonstrable clamp connections and have thin walls that may or may not be incrusted with a pigment and that are decidedly nonamyloid. The gill trama is regular to somewhat interwoven, and in old specimens the cells are rather irregular in diameter. The subhymenium is thin or very thin and ramose.

The basidia have so far been found to be almost constantly four-spored, not granulose in acetocarmin, and not in any way distinctive in either size or shape. Pleurocystidia and pseudocystidia are not differentiated. Cheilocystidia may be lacking, scattered, or numerous. The cuticle of the pileus consists of a compact layer of narrow subcylindric more or less appressed hyphae, from which scattered oblique or erect hyphae project.

The carpophores are of medium or very large size, thick, fleshy, soft or tough, with a dry context but not leathery. If vascular hyphae are present, they are not colored by sulfoformol. The lamellae are usually sinuate or decurrent but never free. They are often readily separable, however, from the context of the pileus. The stipe is solid, fibrous and fleshy, rather firm to very firm, but never cartilaginous or fistulose, and never brittle or waxy.

The margin of the pileus is never pellucid-striate, but rather frequently short-ribbed to crenulate from early contact with the lamellae at the time the margin is still strongly inrolled. There are no veils, and the development is gymnocarpic, as has been shown by Kühner (5) for *L. tricolor*.

The chemical reactions with ordinary reagents (alkali, acids, formol, phenol, aniline) are weak and not distinctive. In some species the reaction to guaiac is positive. In *L. albissimus* var. *typicus* methylparamidophenol gives a positive reaction only on the margin of the cap and on the lamellae.

The habitat is usually in woods on humus or around very decayed logs, on soil under brush, or on grassy ground near trees. The carpophores usually occur in rings or in irregular groups (gregarious), and apparently the species do not form mycorrhiza.

This definition excludes all genera with nonamyloid spores (Clitocybe, Tricholoma, Paxillus, etc.); all genera and species without clamp connections, with spores having a suprahilar smooth spot and cystidia in the hymenium (Melanoleuca); all genera or species with one or more veils (*Armillaria luteovirens* — "*Melanoleuca portolensis*," as it is described — the species of Catathelasma, Cystoderma, etc.); all genera with free lamellae (those belonging to the Amanitaceae and Leucocoprinaceae); all forms with colored spores and nonregular gill trama (like Paxillus, which is nearer the Boletaceae); all genera with more highly differentiated surface layers on the pileus (Marasmius, Delicatula, Lepiotella, Cystoderma, Hebelomina, etc.); the species of the genus Lentinellus with numerous lactifers that stain in sulfoformol and protrude into the hymenium in the form of pseudocystidia; all species with amyloid tramal hyphae (part of Marasmius, Lentinellus, etc.); and, finally, all genera with Omphalia-like shape and stipe, of thin, cartilaginous, brittle, or waxy consistency and ordinarily fistulose stipes, thin diaphanous or hygrophanous margin of the pileus, and generally small stature (pileus < 30 mm. broad).

Although the genus Leucopaxillus is unquestionably a natural group within the Tricholomataceae, it is by no means isolated. There are a few species of Clitocybe and Tricholoma (*C. maxima* and *T. mongolicum*) that come rather near to *L. giganteus* and its closely related species. Although we fully recognize this relationship, we believe that the amyloid reaction of the spore wall here constitutes a

very usable as well as a natural character by which to distinguish Leucopaxillus from both genera.

The exclusion of *"Melanoleuca" portolensis* Murrill from *Leucopaxillus* is tentative, and eventually it may appear desirable to emend our definition of the genus to include veiled species. Singer studied the type of Murrill's species, but could find no traces of a veil. Since the type is in very poor condition, not much reliance can be placed on the absence of veil remnants, and it is evident that fresh material will have to be found in order to classify the species properly. The following anatomical data were obtained by Singer from his study of the type: spores 5.5–7.8 × (3.5) 4–4.3 (− 5) μ, not strongly but nevertheless distinctly amyloid, hyaline, smooth or very indistinctly uneven, with very thin walls (the unevenness may be due to slight wrinkles in the thin spore wall resulting from incomplete reviving), granulose within and often with a small central droplet. Basidia 27–36 × 5.3–7 μ. Cystidia and cheilocystidia none. Gill trama probably regular, with rather broad hyphae. Hyphae of the cuticle of the pileus appressed and smooth, without an incrusting pigment over their membranes, quite variable in diameter (2.3–21 μ), probably not parallel and often with claviform ends. All hyphae bear clamp connections, and in many the walls are up to 1 μ thick.

If there is really a veil, as is stated in the original description, *M. portolensis* should probably be placed in the genus Armillaria, as restricted by Singer, and in the neighborhood of *Armillaria luteovirens*. Better material is needed, however, to decide this question, since the most important difference between Armillaria sensu stricto and Leucopaxillus consists in the structure of the gill trama and the subhymenium. Since it has been shown that *Tricholoma mirabile* Bres., which is also described as having a veil, belongs in Melanoleuca sensu stricto (non Murrill), there is, theoretically, no reason for excluding veiled species from Leucopaxillus if they do not differ from that genus in other characters.

There is still another small group of species, including *Omphalia Kalchbrenneri* Bres. and its American relatives, that seem to be rather close to Leucopaxillus anatomically, but approach Omphalia externally. They may be interpreted — as they were by Singer (13) for *O. Kalchbrenneri* — as belonging to a section of Xeromphalina Kühner & Maire, characterized by amyloid spores and no pleurocystidia or cheilocystidia, or they may be considered to be a very

sharply separated subgenus of Leucopaxillus containing the small omphaloid species. This group has been excluded from the present account because it clearly represents a phylogenetic series entirely distinct from those now included in Leucopaxillus.

COMMENTS ON THE CHARACTERS OF THE SPECIES

The species of Leucopaxillus are very closely related to one another. In fact, part of them represent smaller taxonomic units than the average conception of a species in the agarics. Because of this the study of the material had to be carried out very carefully, and, since most species from Europe and Africa as well as from the eastern or the western United States have been described under different names, we have tried to compare specimens — wherever possible the type specimens or authentic material — from all these regions.[1] In some only very small differences were found to distinguish these original forms. In general, those from the western United States were more like the European and Asiatic representatives than were those from the eastern part of the United States. Lack of sufficient material has prevented us, however, from assuming the existence in Leucopaxillus of geographic races or subspecies in the sense of Singer (14). We are treating these forms, more cautiously, as varieties until further studies on their distribution establish the proper area for each. Certain described species have been regarded as forms in this work because the typical forms grow in the same territory and no differentiation into races has been found to be likely in them. The characteristics distinguishing them are considered due largely to environmental factors.

Generally speaking, the taste (whether bitter or mild), the quantity of pigment (not its location), the degree of decurrence of the lamellae on the apex of the stipe, and the absolute size of the carpophores are characters that are believed to have no value for the delimitation of species in Leucopaxillus, and we have used them to distinguish only the varieties and forms.

Characters that do have a general or limited value for the delimitation of species are:

[1] In the paragraphs "Material studied" the following abbreviations are used: FH = Farlow Herbarium, Harvard University; Mich. = Herbarium of the University of Michigan; NY = New York Botanical Garden; NYS = New York State Museum (Albany, New York); LE = Cryptogamic Herbarium of the Academy of Science in Leningrad.

1. *The degree of the amyloid reaction of the spore wall as well as the degree of roughness.* — There are two groups of species in Leucopaxillus that differ only in these characters. So far as we know now, a correlation exists between the ornamentation of the spore wall and its chemical composition. The smooth spores are very slightly amyloid, and generally become so only in a certain stage of development (some spores apparently always remain nonamyloid). In species that, under an oil-immersion lens, are seen to have a warty spore surface, the spores always exhibit a strong amyloid reaction. The reason for this apparent correlation is simple. The part reacting the strongest with iodine is the perisporal disrupted layer of the membrane, whereas the subjacent thin main wall does not react with iodine in young spores, and it does so only very slightly in older ones. Since we have found no transitions between the smooth and the warty types of spore, we are using the character for the main division of the genus into two sections: (1) Aspropaxilli (Kühner and Maire, as genus Aspropaxillus, 1934) with smooth spores, and (2) Eu-Leucopaxilli sect. nov. (= Leucopaxillus sensu Boursier and Maire) with warty spores.

2. *Color and type of pigment (if present).* — A very peculiar pigment is found in *L. tricolor;* it changes upon drying or when subjected to different chemical treatments. The incrustation of the walls of the hyphae by a brown membrane pigment in *L. amarus* is also very characteristic. A more unstable pigment is observed in *L. pulcherrimus.* Here the substance is dissolved in the cell sap. The pigment that gives the pale buff to pale incarnate color to certain other species, such as *L. laterarius,* is likewise dissolved in the cell sap.

3. *Frequence of the cheilocystidia.* — *L. amarus* and its forms have rather numerous cheilocystidia. In *L. brasiliensis* they appear to be rather numerous, but in the dried material available for our study they were so incrusted with a dark vinaceous substance that accurate observation of them was greatly hindered. Certain authors have considered the gill edge of *L. amarus* to be heteromorphous, but since many fertile basidia occur among the cheilocystidia, we can describe it at best as only "almost heteromorphous." Scattered cheilocystidia of the same type as those in *L. amarus* are occasionally found in other species not mentioned above.

4. *Size of the spores.* — Careful measurements of the spores of all species of Leucopaxillus (the ornamentations are included in the

dimensions given in our descriptions) show that the character is not very important. It is valuable in only a few species. In *L. laterarius*, *L. gracillimus*, and *L. brasiliensis* the spores do not measure more than 5.5 μ in length, and thus they aid in distinguishing these species. *L. barbarus* was described by Maire as having relatively large spores (we have had no opportunity to verify his measurements, but as a rule they are remarkably exact). Small spores are characteristic of *L. amarus*, and *L. lepistoides* is distinguished from *L. candidus* and *L. giganteus* by its slightly longer spores. In *L. albissimus* var. *subhirtus* the size of the spores was found to vary extremely, from 4 to 7 μ long in one preparation.

5. *Thickness of the subhymenium.* — All species studied by the authors themselves (i.e. all except one of those included in this paper) have very thin ramose subhymenia. R. Maire, however, attributes a more voluminous subhymenium to the species we have not studied, *L. rhodoleucus*.

6. *Attachment of the lamellae and the shape of the inner ends of the lamellulae.* — Although the attachment of the lamellae at the stipe is rather inconstant in some species, especially in *L. albissimus* and *L. amarus*, in others it is relatively constant. *L. tricolor*, *L. laterarius*, and *L. lepistoides* are rather "tricholomoid" in this respect, whereas *L. candidus*, *L. giganteus*, and *L. rhodoleucus* are decidedly "clitocyboid." In the latter three the lamellulae are gradually attenuated, in contrast to the other species, in which the inner ends of the lamellulae are mostly abruptly rounded or very sharply attenuated from a particular level. Sometimes they appear emarginate, and thus resemble the gills of *Armillaria luteovirens*.

7. *Chemical reactions.* — Reactions like those of guaiac and methylparamidophenol may be of some importance in future studies on Leucopaxilli. At present, however, our material is insufficient to allow us to draw any definite conclusions.

Concerning the evolution of the species of Leucopaxillus, there cannot be any doubt which of the two sections is the more primitive. In the Aspropaxilli not only is the amyloid reaction of the spores, a character of the more highly evolved forms, less evident than in the Eu-Leucopaxilli, but also the pigmentation and the uniform structure of the hymenium belong to a more simple type of development. There seems to be great variability in the forms of the *giganteus* group

rather than a complex of highly specialized and localized forms or races, such as has been observed in the more recently evolved group. In addition, the connection with other genera is more evident in the Aspropaxilli. All groups approaching the genus Leucopaxillus to such a degree that they can be considered related to it have smooth spores. *Omphalia Kalchbrenneri*, *"Melanoleuca" portolensis*, and *Clitocybe fellea* sensu Kauffman all have smooth spores and therefore cannot be compared with the Eu-Leucopaxilli. Further, it should be noted that the number of species is considerably less in the Aspropaxilli than in the Eu-Leucopaxilli.

Only in Europe and North America have sufficient studies been made to indicate the relative abundance of Leucopaxilli in the agaric flora. From a study of dried material Singer discovered that there were two South American species among Rick's Brazilian agarics. At the present time the known species are distributed in South America (Brazil), in North America from California to Florida and north into Canada, and in the Eastern Hemisphere from northern Scandinavia to French North Africa. In addition, *L. amarus* has been found in South Africa. *Clitocybe eucalyptorum* Clel. (the reaction of the spores in iodine is not known) from Australia probably belongs here also. In the Altai Mountains of Asia *L. candidus* has been collected up to the timber line (Singer, 12). In the Caucasian Mountains *L. amarus* (f. *typicus*) has been reported by Singer (11), and *L. candidus*, *L. amarus*, and *L.* (*albissimus* var.) *paradoxus* by Vassilieva (15). R. Maire, in several lists, reported *L.* (*albissimus* var.) *paradoxus*, *L. barbarus*, *L. rhodoleucus*, and *L. lepistoides* for North Africa. All but one of the species and varieties reported for Africa and Asia have also been observed in either Europe or North America. Out of a total of eighteen species and varieties of Leucopaxillus thirteen have been observed in North America, eight in Europe, five in Africa, three in Asia, two in South America, and one (?) in Australia. Further investigations will doubtless add a number of species from South America, Australia, Asia, and Africa, but on the basis of present data North America appears to be the center of distribution for the genus.

KEY TO SPECIES

I. Aspropaxilli: spores smooth, slightly amyloid
  A. Lamellae decurrent, lamellulae not abruptly rounded; stipe not grayish in old specimens or in properly prepared exsiccati; lamellae arcuate and rather narrow
    1. Lamellae white, eventually becoming merely sordid or pallid; old pilei whitish ..... 1. *L. candidus*
    2. Lamellae if white at first soon with a creamy or buff tint and eventually becoming almost alutaceous; old pilei cream buff to chamois ..... 2. *L. giganteus*
  B. Lamellae mostly and at least partially sinuate or emarginate; lamellulae rather abruptly rounded; stipe grayish in old specimens; lamellae subventricose in the marginal third, rather broad (up to 12 mm.) ..... 3. *L. lepistoides*

II. Eu-Leucopaxilli: spores more or less warty, very strongly amyloid
  A. Cheilocystidia scattered or absent, pigment of pileus lacking or not incrusting the walls of the hyphae of the cuticle with dark reddish-brown areolae, warts or rings
    1. Lamellae white, rarely yellow or pinkish, never becoming vinaceous to purplish brown in dried condition
      a) Pileus without hygrophanous spots. Subhymenium thin, (about one third to one half the diameter of the hymenium); lamellae white or creamy, rarely yellow
        (1) Pileus never with a pinkish flush and never bright yellow, but pure white to cream-color or pale buff, pale tan, etc. At least some of the spores measuring longer than 5.5 μ when mature. Taste bitter or mild. On needles or on leaves or on anthills
          (a) Stipe normal (central), not on anthills ... 4. *L. albissimus*
          (b) Stipe long, eccentric, arising from anthills. Odor fetid in drying. Taste sweetish but disagreeable 5. *L. nauseosodulcis*
        (2) Pileus, stipe and context under cuticle yellow. Spores 4–5.8 μ long. Taste mild. On humus under hardwoods 6. *L. pulcherrimus*
        (3) Pileus ordinarily with a flush of pink, sometimes white. Spores never larger than 5.5 μ. Taste decidedly bitter. On humus under hardwoods ..... 7. *L. laterarius*
      b) Pileus with hygrophanous spots when fresh. Subhymenium rather thick (about three fourths the diameter of hymenium). Lamellae at first pinkish or pinkish white ..... 8. *L. rhodoleucus*
    2. Lamellae distinctly yellow, pale yellow, sulphur or cream-color, becoming vinaceous to purplish brown in dried specimens
      a) Pileus dark violet, ashy green around margin ... 9. *L. brasiliensis*
      b) Pileus pinkish buff to dull tan ..... 10. *L. tricolor*
  B. Cheilocystidia numerous. Hyphae of the cuticle of the pileus more or less incrusted by a brown or reddish-brown pigment, which forms warts, areolae, or rings on the hyphal walls. Hyphae rarely not incrusted
    1. Stipe 8–15 (40) mm. thick ..... 11. *L. amarus*
    2. Stipe 2 mm. ± thick ..... 12. *L. gracillimus*

SECTION I: ASPROPAXILLI (MAIRE) S. & S.

1. *Leucopaxillus candidus* (Bres.) Singer, Rev. d. Mycologie, 4:68. 1939

Clitocybe candida Bres. Fung. Trid., 1:16, pl. 18. 1882. Icon. Myc., 4:172. 1928.

(?) *Agaricus giganteus* Sibthorp, Flora Oxon., p. 420. 1794. Sowerby, Engl. Fung., pl. 244. 1800.

Illustration: Bresadola, *l. c.*

Pileus 60–200 mm. broad, convex or somewhat flattened at first, becoming somewhat depressed in age, glabrous but at first pubescent at the involute margin (rarely faintly squamulose in some Altaian specimens), smooth or rarely (in some Altaian collections) ribbed-crenulate at the margin, white, later very pale and dirty brownish white, especially in the center, sometimes becoming buff-colored (particularly in drying); context white, firm, odor weak, farinaceous or spermatic (like that of *Inocybe geophylla*), taste agreeable, mild; lamellae white, becoming pallid or dirty white, narrow, easily separable from the context of the pileus, crowded to close; stipe 40–80 mm. long, 20–35 mm. thick, equal or sometimes slightly ventricose, pure white (at least at the apex and base in the younger plants), remaining white or becoming very pale dirty brownish white, surface smooth or more rarely coarsely scaly downward, usually distinctly furfuraceous-squamulose or pubescent-scurfy at the very apex.

Spores pure white in mass, 6.5–8 × 3.3–4.5 μ, hyaline, smooth, some very slightly or distinctly but never strongly amyloid, some (probably the younger ones) nonamyloid, ellipsoid, with little or no depression; basidia 22–40 (45) × 5–7.7 μ, four-spored; cheilocystidia none; gill trama more or less regular, consisting of filamentous hyphae about 4 μ thick, lactiferous hyphae occasionally found among them; hyphae of the scales of the stipe 2.5–5 μ thick; cuticle of the pileus compact, of interwoven, appressed, thin-walled hyphae 2.3–8.8 μ thick, clamp connections regularly present.

Habitat. — In open mixed woods and in subalpine meadows near conifer trees; also in coniferous woods among needles and on grassy soil, mostly in the mountains up to the timber line (where it is found under Larix). Gregarious, often in large fairy rings. July-October.

Distribution. — In the Alps in Europe and in the Caucasus and

Altai Mountains in Asia. Other localities mentioned in the literature need confirmation. See "Observations."

Material studied. — Authentic material from Trento, coll. and det. Bresadola (NY). Two collections of fresh specimens from the mountains around the Kurai Step, Oirotia, near the Mongolian border, coll. and det. Singer (LE). Specimens from the Caucasian Reservation, Malaya Laba River, coll. Vassilieva, det. Singer (LE).

Observations. — This species is very close to *L. giganteus* (Fr.) Singer, but can be distinguished from it by the color of the gills of mature or old fruiting bodies. Bresadola indicated that his species occurred in North America also. This statement was probably based on a specimen that he identified and that is now preserved in the Farlow Herbarium. The spores are not amyloid and, consequently, it cannot be placed in Leucopaxillus. The only American material likely to belong to *L. candidus* was collected by Smith in Michigan. Since the specimen is rather small and was found in a quite different habitat, it probably is more accurately identified as a young stage of *L. giganteus*. Its microscopic characters allow such a disposal of it. It would not be surprising to find *L. candidus* in the Pacific coast states, but at present we have no records of its occurrence in that area.

2. *Leucopaxillus giganteus* (Fr.) Singer, Schweiz. Zeitschr. Pilzk., 17 : 14. 1939

Agaricus (*Clitocybe*) *giganteus* Fr., Monogr., p. 118. 1857 (A. Peterson, Monogr. Clit., p. 22. 1854).
Paxillus giganteus Fr., Hymen. Eur., p. 401. 1874.
Clitocybe gigantea Quélet, Champ. Jura et Vosges, 1 : 88, pl. 3, fig. 3. 1872.
Omphalia geotropa gigantea Quélet, Enchir. Fung., p. 23. 1886.
Aspropaxillus giganteus Kühner & R. Maire, Bull. Soc. Myc. Fr., 50 : 13. 1934.
Melanoleuca oreades Murrill, Mycologia, 5 : 218. 1913.

Illustrations:
For the spores see Figure 3 (see p. 100).
Fries, Sver. Ätl. och Gift. Svamp., pl. 86.
Quélet, *l. c.*
Hussey, Illus. Brit. Mycol., pl. 79 (pileus very white).
Barla, Champ. Alp. Mar., pl. 56 (good).
Letellier, Hist. Champ., pl. 682 (good).
Cooke, Illus. Brit. Fung., pl. 150 (106).
Konrad et Maublanc, Icon. Sel. Fung., 3, pl. 290 (good).
Lange, Flora Agar. Danica, pl. 33, fig. F.
(The figures of Sicard, Britzelmayr, and Sowerby are poor or incorrect.)

Pileus 100–450 mm. broad, slightly convex to almost flat, rarely depressed from the beginning, soon becoming depressed over the center and the margin arched, finally infundibuliform, never umbonate, slightly moist at first, drying quickly and not viscid, when young glabrous except for the pubescent-involute margin (surface with the feel of kid), later often more or less rimulose or even faintly squamulose, especially in the center, often grooved at the margin, color creamy-white, soon becoming darker, particularly in the center, varying from about "cream buff" to "chamois" (R.), rarely with pale rusty-brownish places; context white or whitish, watery in old specimens, firm, finally soft in the pileus, odor weak, farinaceous or "mossy" (Quélet), "somewhat suggestive of skunk cabbage" (Murrill), taste mild; lamellae white or more often whitish with a creamy or buffy tint, finally almost alutaceous, crowded to very close, decurrent, narrow (when compared with the thickness of the flesh and diameter of the pileus), 5–13 mm. broad, usually straight, but sometimes crisped, anastomosing and sometimes forked, separable from the pileus, lamellulae subsinuate, attenuate; stipe 45–75 mm. long, 22–50 mm. thick, solid, rather short, equal or irregular, occasionally ventricose or with an inflated base, fibrous and glabrous, smooth or somewhat wrinkled in old specimens, rarely split longitudinally, white to concolorous with the pileus.

Spores pure white in mass, 5.3–8 × 3–5.7 μ, hyaline, smooth, ellipsoid to ovoid, mostly without an oil drop, with little or no depression, amyloid (as in *L. candidus* or more distinctly so); basidia 35 × (5.5) 6–6.5 (8) μ, four-spored; cheilocystidia none; gill trama subregular, consisting of interwoven hyphae which are rather thick in mature carpophores (5–15 μ), lactiferous hyphae none or very few.

Habitat. — In open mixed woods and in hilly places under spruce and fir, very often in gardens and parks on grassy soil, mostly in the plains and up to the lower limit of the mountain zone. Gregarious, often in large fairy rings. August-October.

Material studied. — Fresh specimens were obtained from the Forêt de Fontainebleau, France, under oak and conifers at the edge of the woods, coll. and det. Singer; from the region of the Donets River, U. S. S. R. (LE; det. Singer), and from Warrensburg, New York, coll. Smith (Mich.). Type specimen of *Melanoleuca oreades* from Washington (NY). Dried specimens from Whitmore Lake,

Michigan, coll. Kauffman (Mich.); one fruiting body from Kent Lake, Oakland County, Michigan, 1937, coll. Smith (Mich.); from Lyon, France, coll. and det. M. Josserand, 1932 (Mich.).

Observations. — There appears to be no very sharp line of demarcation between *L. giganteus* and *L. candidus.* It is possible that *L. candidus* is only a mountain variety of *L. giganteus.* We consider it unlikely that *L. candidus* is merely the pale immature stage of *L. giganteus,* although many reports of the former in the literature really apply to the young stages of the latter. It is surprising to find the colored species called *giganteus* Sowerby in all manuals and mycological papers up to the present time. An examination of Sowerby's publication shows that he did not describe the plant as new, but referred instead to Sibthorp, *Flora Oxonensis,* and expressed some doubt whether his fungus was really identical with *Agaricus giganteus* Sib., which Sibthorp described as a wholly white agaric, with a citation of Buxbaum, who described a similar large white species from Duderhof, near St. Petersburg (Leningrad), Russia. An accurate disposition of all these descriptions and illustrations is difficult, but they appear to apply to what is now called *L. candidus* rather than to the fungus Fries placed in Agaricus or *Paxillus giganteus.* Indeed, Fries was the first to interpret the species of Sibthorp as the colored agaric we now know as *Leucopaxillus giganteus.* He also appears to have been the first to give the wrong citation — *A. giganteus* Sow. Since, however, agaric nomenclature officially starts with Fries, we are using what seems to be his concept and are citing him as the original authority.

Kauffman (3) included *Clitocybe gigantea* in the Michigan flora, but gave the size of the spores as $5 \times 3\ \mu$. Smith's collection from the Adirondacks was also characterized by rather small spores — 5 6.5 μ. From our study it appears that in American material the spores are usually closer to the lower edge of the range given, and that in European specimens they are near the upper edge of the range. The difference appears to be too slight, however, to justify erecting forms or varieties. One other variation we noted was that in European material there is a tendency for the margin of the pileus to be ribbed or grooved a little more regularly than in American material, but here again we may be dealing merely with variations between collections. Kauffman emphasized the ribbed character of the margin of the pileus in his description.

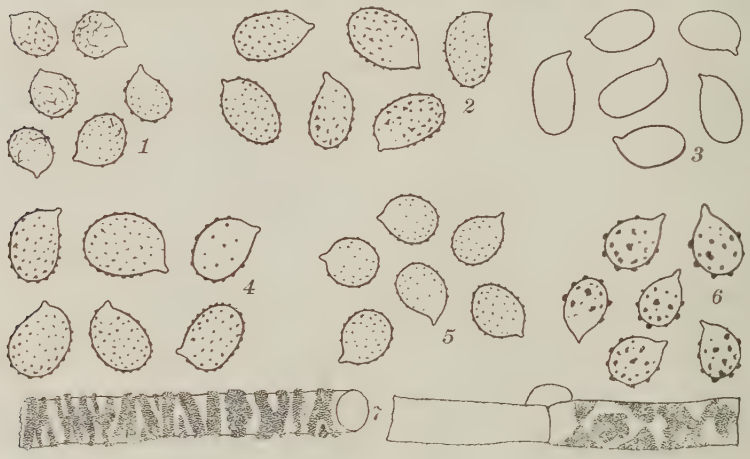
3. *Leucopaxillus lepistoides* (R. Maire) Singer, Schweiz. Zeitschr. Pilzk., 17 : 14. 1939

Tricholoma lepistoides R. Maire, Bull. Soc. Myc. Fr., 40 (4) : 301. 1926.
Aspropaxillus lepistoides Kühner & Maire, Bull. Soc. Myc. Fr., 50 : 13. 1934.

Illustrations: R. Maire, *l. c.*, pls. 19 and 20, fig. 1.

(*a*) Description of the African material (from Maire, *l. c.*):

Pileus white, then with greenish-gray spots near the center, finally often tinged with pale ochraceous, glabrous but sometimes



FIGURES 1–7

FIG. 1, spores of *L. laterarius;* FIG. 2, spores of *L. albissimus* var. *paradoxus* f. *albiformis;* FIG. 3, spores of *L. giganteus;* FIG. 4, spores of *L. tricolor;* FIG. 5, spores of *L. amarus* f. *typicus;* FIG. 6, spores of *L. pulcherrimus;* FIG. 7, hyphae from cuticle of *L. amarus* f. *typicus*

The figures were drawn with the aid of a camera lucida and as reproduced are magnified approximately 1650 times.

becoming slightly scaly from appressed scales on the margin, opaque (reminding one of kid when touched), very slightly viscid, then dry, with a more or less separable cuticle and a sterile involute margin, which soon becomes merely incurved, thick, not very acute, faintly tomentose, smooth and not wavy; convex then flattened, not or only a little depressed in the center, very fleshy, 100–200 mm. in diameter; context white, sometimes blue within at the base, more

or less soft and spongy, fleshy in the pileus, fibrous-fleshy in the stipe, odor like anise, very specific, taste mild; chemical reaction: guaiac −, HNO_3 −, CH_3CO_2H −, H_2SO_4, surface of young pileus pinkish gray, old pileus olive ochre, blue context of the base of the stipe yellow; lamellae whitish, finally pale tallow color, not anastomosing (except for the rear part), crowded, thin, separable from the context of the pileus, often more or less connate or anastomosing near the stipe, some forked, arched and then somewhat ventricose near the margin, attenuate at the cap margin, rounded or subattenuate at the stipe, sinuate-adnate or a little decurrent, then often adnate-emarginate, broad (up to 12 mm.), lamellulae abruptly rounded and even emarginate at times; stipe white at times, finally becoming slightly grayish, faintly pubescent, then glabrous or scarcely pruinose at the apex, scarcely fibrous-striate, dry, solid, confluent with the pileus, subequal or subbulbous, more or less blunt above a part of the mycelium mixed up with the soil.

Spores 7.5–9 × 4.5–5.5 μ, hyaline, smooth, amyloid (in the original description J–), ellipsoid, with one or several droplets; basidia 30–38 × 7–8 μ, four-spored; cystidia and cheilocystidia none; subhymenium ramose, thin (one half to one third thickness of hymenium); gill trama regular, consisting of more or less flexuose hyphae 7–14 μ thick.

Habitat. — Pastures, brushy woods, plantations, under Eucalyptus, Olea, Lentiscus. Solitary to gregarious. Autumn and spring.

Distribution. — Algiers and possibly North America (see the following description).

(*b*) Description of American specimens:

Pileus in the dried condition "light buff" with "Sayal brown" (R.) patches, opaque or somewhat shining, with an abruptly narrowed but fertile margin that shows abruptly narrowed lamellae, glabrous, smooth, convex, large; flesh whitish, not extremely thick; lamellae in dried condition dirty pale yellowish, rather broad, broadest near the margin, with or without very faint anastomosing veins, decidedly sinuate, lamellulae rather abruptly rounded and scarcely tapered at end toward the stipe; stipe smoke gray on the dried plant, smooth, glabrous, solid in upper half, equal, lower half ventricose or bulbous, thick and short (shorter than the diameter of the pileus or even its radius); spores 7.5–9 × 4–5 μ, very slightly amyloid, smooth, ellipsoid, flattened but not depressed on the inner side; basidia

30–35 × 7–8 μ, four-spored; cystidia and cheilocystidia none; subhymenium ramose, thin; gill trama as in *L. giganteus*.

Habitat. — Probably in grassy open woods. November.

Material studied. — Specimens from the Don Valley, Toronto, Ontario, Canada, coll. G. S. Bell (FH).

Observations. — Inasmuch as *L. lepistoides* has been recognized previously only from North Africa, it is very interesting to find a fungus almost identical with it in southeastern Canada. We regard our identification of Bell's specimen as tentative, since we have studied it only in the dried condition and have not seen authentic African specimens. For this reason descriptions of them are given separately.

SECTION II: EU-LEUCOPAXILLI S. & S.

4. *Leucopaxillus albissimus* (Peck) Singer, Schweiz. Zeitschr. Pilzk., 17 : 14. 1939.

Agaricus (*Clitocybe*) *albissimus* Peck, Bull. Buffalo Soc. Nat. Sci., 1 (2) : 45. 1873.
Clitocybe albissima Sacc., Syll. Fung., 5 : 158. 1887.
(For other "species" belonging to *L. albissimus* sensu lato see synonymy of the varieties.)

Illustration: None (for illustrations of varieties other than the type variety see under respective varieties).

L. albissimus sensu lato is divided into several varieties, which are keyed out at the conclusion of the treatment of this species. It has been necessary to give here complete descriptive data on all the varieties in order to make them clearly recognizable to other investigators, to bring into sharp focus the amount of segregation that is in progress in this species, and to avoid obscuring slight but constant differences in material from other regions. If only *Clitocybe albissima* and *C. paradoxa* were compared they would be considered independent species. Since, however, we have found a whole series of constant but little-differentiated populations connecting the extreme forms, we were forced to include them all under the oldest name — *L. albissimus*.

(*a*) Var. *typicus*

Pileus (30) 50–60 (70) mm. broad, convex but becoming more or less expanded, margin involute and slightly subtomentose when

young, usually ribbed but sometimes smooth, surface glabrous, smooth or rarely faintly rimose-areolate in age, scarcely shining, pure white, remaining white when dried or very rarely subalutaceous over the disc; context pure white, not watery, soft, unchangeable, odor aromatic and sweet but often weak, taste farinaceous-bitter; lamellae white and staying so even in dried material (if properly dried), crowded, or subcrowded, occasional individuals forked at the base, mostly nonanastomosing, adnate with a decurrent tooth or simply decurrent, some with short riblike proliferations down the apex of the stipe, ribs not anastomosing, moderately broad (up to 6 mm.), lamellulae abruptly rounded at inner extremity; stipe 40–70 mm. long, 7–15 mm. thick, subequal but the base often bulbous with adherent remnants of leaves or needles, white-mycelioid, not strigose, solid, white, subglabrous or somewhat fibrous-scabrous (especially at the apex).

Spores pure white in mass, 5.5–7.5 (8.5) × 4.2–5.5 μ, hyaline, with isolated strongly amyloid warts 0.3–0.4 μ high, ellipsoid to ovoid, depression slight or absent; basidia 24–36 × 6.5–8.5 μ, four-spored; pleurocystidia none, cheilocystidia extremely rare or lacking; subhymenium ramose, thin; gill trama subregular, consisting of hyphae 1–5 μ thick, with scattered lactifers, clamp connections abundant; reaction with methylparamidophenol: only the lamellae and the margin of the pileus dark violet.

Habitat. — Mostly in mixed woods on leaves and needles together on the forest floor, sometimes in pure hardwood or conifer stands. Solitary, gregarious, or often in rings. Usually in September.

Distribution. — Eastern part of North America: New York, New Hampshire, Ontario, and Michigan.

Material studied. — Type collection, Croghan, New York (NYS). Fresh material from Huntington Forest, Newcomb, New York, coll. and det. Singer (FH). Dried material from Bow, New Hampshire, coll. Blackford (FH); from Richmond Hill, Ontario, University of Toronto Crypt. Herb. no. 9598 (FH); from Michigan, coll. and det. C. H. Kauffman, Sept. 9, 1906, and Aug. 10, 1909 (Mich.); from Au Train, Michigan, 1932, Mains 32–537, det. Smith (Mich.); from University of Toronto Crypt. Herb. no. 3638, coll. G. S. Bell (Mich.).

Observations. — The typical variety of *L. albissimus* is easily known by its bitter taste, medium size, and persistently pure white

color. The pileus is never pubescent-hairy, and the base of the stipe is never strigose.

(*b*) *Leucopaxillus albissimus* var. **piceinus** (Peck) S. & S., comb. nov.

Clitocybe piceina Peck, Bull. Torr. Bot. Club, 3 (4) : 178. 1904.

Illustration: Kauffman, Agar. Mich., II, pl. 154. 1918.

Pileus (50) 60–100 (250) mm. broad, convex with an inrolled margin when young, plane or nearly so in age, surface dry and unpolished (appearing matted-fibrillose under a lens), margin often irregular and frequently ribbed or grooved, the inrolled portion sometimes tomentose, color whitish or cream-color, often becoming tan over the disc, generally pale sordid-ochraceous in age; context white, unchanging, thick, firm, odor somewhat pungent and unpleasant, taste disagreeable and bitter; lamellae whitish or in age tinged yellowish, rather dark yellow in dried plants, close to subdistant, narrow, readily separable from the context of the pileus and cracking readily transversely in age, short-decurrent or extending down the stipe in anastomosing lines, lamellulae rounded at the inner extremity, stipe 30–80 mm. long, 8–30 mm. thick, often eccentric, when young clavate to somewhat bulbous, but elongating and nearly equal in age, solid and firm but when old becoming spongy within, white or becoming tinged with buff, unpolished or becoming finely fibrillose, especially toward the base, often very markedly strigose, smooth and glabrous in the apical region or faintly fibrillose-pruinose.

Spores white in mass, 5.5–8 × 4.5–5 μ, hyaline, depression lacking or very slight, ellipsoid to ovoid, moderately rough to decidedly warty, the warts about 0.4 μ high and strongly amyloid; basidia 33–41 × 6–8 μ, four-spored; cheilocystidia very scattered, filamentose, 20–32 × 3 μ; subhymenium ramose, thin; gill trama subregular, the hyphae narrow and interwoven.

Habitat. — On needle beds in conifer forests, rarely on logs. Kauffman reported this species as growing under maple, but his specimens are labeled "in mixed woods." The types and all material of Murrill, collected in the Adirondacks, grew in conifer habitats. Gregarious, scattered, or solitary. September-October.

Distribution. — Nova Scotia, Adirondack Mountains of New York, Ontario, Michigan, Illinois, Oregon, and Tennessee.

Material studied. — Peck's type from Chicago, on spruce needles, coll. W. S. Moffat and L. H. Watson (NYS). Numerous collections from the Adirondack Mountains, New York, all on coniferous débris or under conifers. (Even specimens whose habitat is described as "under maple" have needles of balsam, spruce, hemlock, or pine in the débris adhering to the stipe.) Coll. and det. (as *Melanoleuca albissima*) by W. A. Murrill (NY; NYS). The following collections from the University of Michigan Herbarium have also been studied: Kauffman, Elkmont, Tennessee, Sept., 1916; Adirondacks, New York, Sept. 10, 1914, and Sept. 1, 1921; Takilma, Oregon, Dec. 10, 1925; Detroit, Michigan, Aug., 1905; Marquette, Michigan, Sept., 1906; G. S. Bell, Aug., 1932, University of Toronto Crypt. Herb. no. 3621, Ontario; Smith and Wehmeyer, Sept., 1931, Nova Scotia; L. C. C. Krieger, Kelly Herb. no. 1566, Ontario; Mains, Aug., 1932, Michigan; Smith, Sept., 1929, Michigan.

Observations. — This variety is distinguished from the others by the bitter taste together with yellowish tints on old and dried specimens. The anastomosing ridges at the apex of the stipe are found to be fairly constant and when present aid materially in identifying specimens.

(*c*) *Leucopaxillus albissimus* var. **subhirtus** (Peck) S. & S., comb. nov.

Agaricus (*Clitocybe*) *subhirtus* Peck, Ann. Rep. New York State Mus., 32:25. 1880.
Clitocybe subhirta Peck, Bull. New York State Mus., 1 (2):11. 1888.
Illustration: none.

Pileus 25–75 mm. broad, convex, soon more or less expanded and sometimes becoming slightly depressed, never infundibuliform, surface dry and somewhat hirsute, especially near the margin, becoming glabrous, margin involute but regular and even, color pale yellowish buff becoming paler in age; context whitish; odor unknown; taste bitter; lamellae whitish or pale yellowish, dull yellow in dried specimens, close to crowded, rather narrow, adnate or more often decurrent, sometimes with faint ridges or lines extending down the apex of the stipe (but not so long as in var. *piceina* and not anastomosing); stipe 25–50 mm. long, 6–10 mm. thick (about as long as the pileus is wide), subequal or thickened downward, stuffed

(or hollow; see Peck), whitish, concolorous with the pileus in dried plants, glabrous except for a velutinous zone at the lamellae, base not strigose but attached to leaves by a copious white mycelium.

Spores 4–7 × 3.5–5.5 μ, hyaline, ellipsoid or ovoid to subglobose, rough or with scattered warts (warts up to 0.5 μ high and strongly amyloid), depression slight or absent; basidia 23–32 × 5.5–6.5 μ, four-spored; cheilocystidia not found; gill trama slightly interwoven to more or less regular, the hyphae varying in size (1) 2–9 (12.5) μ thick; hairs of the pileus thin-walled, hyaline, smooth, more or less cylindric; hyphae of the context with clamp connections.

Habitat. — On humus in frondose woods. July-September.

Distribution. — New York to Ohio.

Material studied. — The type collection from Brewertown, New York, and one other authentic collection (both at NYS). Dried specimens from Oxford, Ohio, coll. and det. (as *Clitocybe albissima*) by Bruce Fink (FH).

Observations. — This variety is rather near to the preceding, but differs in the characters of the apex of the stipe and in the tomentose pileus. There may also be a difference in the variability of the spore size, and there appears to be a constant difference in habitat. In addition, the mycelium at the base of the stipe in var. *subhirtus* is softer than that of var. *piceinus* and is snow white.

(*d*) *Leucopaxillus albissimus* var. **Kauffmanii** S. & S., var. nov.

Pileo albido, glabro praeter marginem valde pubescentem, levi, depresso; lamellis alutaceoflavis in siccitate atque 3 mm. ± latis, haud anastomosantibus, simplicibus, profunde decurrentibus. Sporis 4–7.4 × 3.2–6 μ, magnitudine et forma variabilibus, amyloidibus, verrucosis. Stipite albido, deorsum incrassato, subpubescente ad apicem, ad basim autem albomycelioso. Carne alba, miti. Habitat ad folia in quercetis. Novembri mense, Ann Arbor, Michigan.

Singer recorded the following data from a study of Kauffman's collection: Pileus medium-sized, infundibuliform, smooth, glabrous except at the margin, where it is strongly pubescent and involute, whitish; context white; odor unknown; taste mild in the dried material; lamellae alutaceous yellow in dried condition and about 3 mm. broad (narrow), not anastomosing, simple, deeply decurrent; lamellulae rather abruptly sinuate to emarginate, only a few sub-

sinuate-attenuate; stipe whitish, thickened downward, glabrous except at the very apex, where it is very faintly pubescent, base white-mycelioid and covered with attached leaves. Spores 4–7 × 3.2–6 μ, hyaline, rather irregular in size and shape, mostly ellipsoid, with little or no depression, with strongly amyloid isolated warts. Basidia 23–37 × 5.2–6.5 μ, four-spored. Gill trama subintermixed to almost regular, consisting of hyphae 2–9.5 μ thick.

The following description is transcribed from Kauffman's notes on the fresh specimens: Pileus up to 50–70 mm. broad, at length depressed, sometimes umbilicato-depressed, appressed-floccose, pale yellowish to buff or creamy whitish, even, not truly pliant, margin persistently incurved (narrowly); context yellowish to whitish, 4–5 mm. thick toward the stipe, tapering gradually to the margin; lamellae yellowish, more so in age, adnate to decurrent, close, moderately broad (5–6 mm. in the middle), acuminately narrowed to the stipe, edges entire; stipe moderately stout, 40–50 mm. long, 8–12 mm. thick, incrassate below, floccose-silky at junction with gills, heavy-white-mycelioid below, silky-fibrillose and glabrescent elsewhere; spores 5–6 × 4–5 μ, gill trama subinterwoven; cystidia and sterile cells none.

Habitat. — On leaves in oak woods. November.

Distribution. — Known only from the type locality.

Material studied. — A collection by C. H. Kauffman, near Ann Arbor, Michigan, November 14, 1926, type (Mich.).

Observations. — Kauffman identified the collection as *Clitocybe subhirta*, but it differs from Peck's material in the form of the pileus, the less uniform and less buffy color of the whole carpophore, and the mild taste of the dried plant as well as in the deeply decurrent lamellae. Kauffman did not give any information on the odor or the taste of the fresh specimens, and his line drawings, with his notes, indicate a pileus only slightly depressed, whereas in the specimens it is more or less infundibuliform, with an incurved margin. The change in shape was doubtless caused by the shrinking of the flesh as the carpophores dried. Since such a change did not take place in the type of *subhirtus*, it is likely that the difference in the shape of the pileus is distinctive. There is no evidence of overheating in the type of var. *Kauffmanii*. The taste should distinguish between these two very readily if the other characters noted are found to intergrade.

(*e*) *Leucopaxillus albissimus* var. **lentus** (Post apud Romell) S. & S., comb. nov.

Agaricus (*Tricholoma*) *lentus* Post apud Romell, Botan. Notiser for the year 1895 (1) : 65. 1895.
Tricholoma lentum Sacc., Syll. Fung., 14 : 72. 1899.

Illustration: Plate I.
Exsiccati: Lundell & Nannfeldt, Fungi Exsiccati Suecici, No. 202. 1936.

Description of forma **typicus** (*Tricholoma lentum* Rom., *l. c.*). Some of the macroscopic data are adopted from Romell.

Pileus 20–80 mm. broad, fleshy, convex, becoming plane or with a shallowly depressed disc, the margin frequently wavy, surface dry, more or less woolly fibrillose when young, appressed-fibrillose in age, white or disc faintly tinged buff in extreme age, not changing where handled, the disc becoming pale tan at times in drying; flesh white, firm, odor weak, taste mild; lamellae white, very pale cream-color in dry specimens or very pale buffy tan, adnate and even slightly sinuate (then with a decurrent tooth or with longitudinal ridges extending down the apex of the stipe), often merely decurrent or more or less irregularly decurrent; lamellulae abruptly sinuate; stipe variable in size and shape, 30–60 mm. long, 10–18 mm. thick, clavate to equal, solid, concolorous with the lamellae, the apex more or less ribbed by the decurrent lines of the lamellae, with a cottony-white mycelium holding débris to the base.

Spores 6–8.2 × 4–5.5 μ, rough with scattered strongly amyloid warts, ellipsoid or almost ovoid, with scarcely any epihilar depression, sometimes with one oil drop; basidia 29–36 × 8–9 μ, four-spored; pleurocystidia none; cheilocystidia scattered, fusoid-subulate, about 5 μ thick, acute; subhymenium ramose, thin; gill trama subregular; hyphae of the flesh with clamp connections.

Habitat. — On thick layers of decaying needles of *Picea excelsa*. Gregarious. In Washington it was found under Douglas fir and species of Abies. September-November.

Distribution. — Scandinavia and Washington (see forms 1 and 2 also).

Material studied. — Authentic material coll. and det. Romell, in Sweden (NY); Fungi Exsiccati Suecici no. 202 (LE); fresh specimens, Smith no. 17392, from Washington (Mich.).

Observations. — This variety is distinguished from most of the

forms met with in the eastern United States by its mild taste. It is much smaller than var. *paradoxus* and its form *albiformis*. Var. *barbarus*, which is not now known to occur in North America, appears to be closest to it. Two additional forms from Washington are described below.

(1) *Leucopaxillus albissimus* var. *lentus* f. **olympianus** S. & S., f. nov. Plate II

Habitu magis clitocybiformi vel constantius clitocybiformi omnibusque in partibus paululo maior est.

Pileus 30–90 mm. broad, convex with an involute, cottony margin, becoming plane or the margin uplifted slightly, surface dry and appearing matted-fibrillose under a lens, the margin sometimes more or less ribbed, dull white when young, soon creamy on the disc or in age, sometimes becoming pale tan, the margin remaining whitish or becoming chalk-white; context white, 10–12 mm. thick in the pileus at the stipe, tapered abruptly, soft and cottony, odor pungent-subfarinaceous, taste mild or slightly farinaceous in old caps; lamellae white to pale cream-color and staining yellowish brown in age, close to almost subdistant (56–62), some forked near the stipe, broad (7–10 mm.), tapered to the cap margin, with even or wavy edges, adnate but soon developing a decurrent tooth and finally quite decurrent; stipe 30–60 mm. long, 10–15 mm. thick at the apex, equal or clavate, dull white, unpolished, more or less white-tomentose around the base and with a copious white mycelium holding débris to the base in a compact mat, otherwise glabrous.

Spores 6–8.5 × 4.5–5.5 μ, hyaline, with strongly amyloid warts, 0–1 oil drop, ellipsoid to almost ovoid, lacking or with only a slight depression; basidia 28–35 × 7.5–8.3 μ, four-spored, rarely two-spored; pleurocystidia and cheilocystidia none; subhymenium ramose, about one third to one half the thickness of the hymenium; gill trama rather regular, consisting of interwoven thin hyphae (3) 4–5 (10) μ thick.

Habitat. — On needle carpets under Douglas fir. Gregarious. September.

Distribution. — Known only from the type locality, Lake Mills, Olympic Mountains, Washington, Sept. 26, 1941, A. H. Smith nos. 17257, 17333.

Observations. — This form differs from the typical form in its

stature. It has the aspect of a Clitocybe rather than that of a Tricholoma.

(2) *Leucopaxillus albissimus* var. *lentus* f. **furcatus** S. & S., f. nov.

Habitu magis clitocybiformi vel constantius clitocybiformi, lamellis furcatis.

Pileus 40–70 mm. broad, obtuse or gibbous when young, obscurely umbonate to plane in age, the margin opaque and involute at first, in age the margin spreading or slightly raised, snow-white because of a thin coating of appressed white fibrils, when wet or in age more or less glabrescent; context white, not changing when bruised but becoming more or less tawny in age, moderately thick and firm, odor none (old water-soaked specimens fragrant), taste mild; lamellae white to cream-color or becoming tawny-brown-spotted when water-soaked, narrow, short-decurrent, close to crowded, frequently forking or anastomosing, lamellulae present but not regularly arranged, abruptly rounded; stipe 30–50 mm. long, 8–12 mm. thick, solid, more or less equal or both apex and base slightly enlarged, white when young but sordid watery-buff in age, with a white mycelium holding the débris together around the base, surface glabrous to thinly appressed-fibrillose but unpolished.

Spores 6–7 × 4–5 μ, warty, the warts strongly amyloid and projecting 0.4–0.5 μ, depression slight or lacking, nearly ellipsoid; basidia 28–33 × 7–7.7 μ; pleurocystidia and cheilocystidia none; gill trama as in f. *olympianus*.

Habitat. — Under Douglas fir. Gregarious. Elevation about 3,500 feet. September.

Distribution. — Known only from the type locality in the State of Washington.

Material studied. — Fresh material from Boulder Creek Trail, Mt. Baker, Washington, coll. and det. E. B. Mains and A. H. Smith no. 16593 (Mich.).

Observations. — This form differs from f. *olympianus* and typical material of the variety in the strongly forked gills, which remind one of *Clitocybe aurantiaca*, and in the covering of the pileus, which reminds one of that of *C. dealbata*. In the field it is not readily distinguishable from a pale form of *C. aurantiaca* that is fairly common in the Olympic and Cascade Mountains.

(*f*) *Leucopaxillus albissimus* var. **barbarus** (Maire) S. & S., comb. nov.

Lepista barbara Maire, Bull. Soc. Myc. Fr., 40 (4) : 303. 1925.
Leucopaxillus barbarus (Maire) Kühner, Bull. Soc. Linn. Lyon, 5 (16) : 125. 1926.
Leucopaxillus barbarus var. *microsporus* Maire, Fungi Catalaunici. Publicacions de la Junta de Ciències Nat. Barcelona, 3 (2) : 76. 1933.

Illustration: Maire, *l. c.*, pl. 24.

Pileus 20–70 mm. in diameter, convex then plane and even a little depressed in the center, regular, then wavy and sometimes difform, with incurved and faintly pruinose margin, which later becomes expanded and glabrous, moist, subviscid, soon dry and appearing as if frozen, with adnate cuticle, glabrous, white, becoming ochraceous in old specimens; context white, very thick in the center, thin toward the margin, elastic, firm in the pileus, tough and fleshy-fibrous in the stipe; odor farinaceous and like that of *Cortinarius purpurascens;* taste mild; guaiac positive; NH_3 negative; lamellae white, dirty yellow in age, crowded, thin, separable from the context of the pileus, rather broad, very soft, arched, attenuate at both ends, deeply decurrent, not anastomosing, lamellulae more or less rounded; stipe white, somewhat villose-subsquamulose at the apex, fibroso-striate, dry, confluent with the pileus, elastic, solid, subcylindrical or slightly attenuate at the base, enlarged under the lamellae, 50–60 × 7–20 mm.; mycelium white, abundant, cobweb-like, incrusting the dead leaves.

Spore print pure white; spores 7–9 × 4–4.5 μ (in var. *microsporus* 6–7.5 × 4.5 μ), hyaline, thin-walled, warty-subechinulate, amyloid; basidia 30–35 × 6–7 μ, four-spored; cystidia none; cheilocystidia none; subhymenium ramose, thin (one half of hymenium); gill trama dense, regular, consisting of scarcely unequal elongated straight hyphae 6–8 μ in diameter.

Habitat. — Woods of *Quercus Mirbeckii* and *Q. Afares* (var. *microsporus* in woods of *Q. toza*). On eocenic sandstone. Gregarious. Autumn.

Distribution. — North Africa and probably in Spain.

Material studied. — None. The description is translated and adopted from Maire, *l. c.*

Observations. — *L. albissimus* var. *barbarus* differs from var. *subhirtus* in its mild taste and the subviscid glabrous pileus. From var.

lentus it differs in its subviscid pileus and habitat. In addition, var. *lentus* is said to have a tricholomoid appearance, which is shown in our photograph, but stature is not a reliable character in that variety and hence should not be emphasized as a difference between the two varieties in question.

(*g*) *Leucopaxillus albissimus* var. **paradoxus** (Cost. & Duf.) S. & S., comb. nov., f. **eu-paradoxus** S. & S., nom. nov.

Clitocybe paradoxa Cost. & Duf., Prem. Suppl. Nouv. Flor. Champ., p. 262. 1896.
Lepista paradoxa Maire, Bull. Soc. Myc. Fr., 40 (4) : 307. 1925.
Leucopaxillus paradoxus Bours., Bull. Soc. Myc. Fr., 41 : 391. 1925. Kühner, Contrib., p. 134. 1926.

Illustrations:
Maire, *l. c.*, pl. 23.
Patouillard, Tab. Anal., Fasc. 7, No. 618. 1889 (as *Lepista amara*).
Konrad et Maublanc, Icon. Sel. Fung., 4, pl. 301.

Pileus 40–100 (usually about 60) mm. broad, convex or with a flattened disc or convex-plane with a somewhat depressed center, color cream-white, then mostly tinted with ochraceous cream-color especially in the center, very faintly rimose-areolate, the space between the areolae being paler; dry and unpolished but glabrous and smooth, the margin involute at first and more or less pubescent, later glabrous and repand and often ribbed-crenulate; flesh white, fairly tough, firm, odor strong, recalling that of *Tricholoma sulphureum* but not exactly resembling it, usually more farinaceous (of "fresh wood" — Kühner), taste disagreeable but mild; lamellae whitish, subdistant to crowded (38–100), rather narrow, not or only rarely forked (often forked, however, at the lines or ridges extending down the apex of the stipe, where they may form a network or a zone of isolated longitudinal ribs), not anastomosing at the bases of the lamellae, separable from the context of the pileus, unequally decurrent, lamellulae abruptly rounded; stipe 30–80 mm. long, 8–25 mm. thick, equal or subbulbous, if bulbous often attenuated below the bulb, solid, white or whitish, mostly covered with small appressed whitish or pale buff squamules or wholly pubescent.

Spores pure white in mass, 5–7.5 × 3.3–4.8 μ, ellipsoid or almost ovoid, with 0–1 oil drop, with strongly amyloid warts; basidia 21–41 × 4–7.5 μ, four-spored; pleurocystidia and cheilocystidia none; subhymenium ramose, thin, gill trama subregular, consisting of

hyphae 3–5 μ thick (those toward the middle of the trama often thicker); cuticle of pileus dense, consisting of thin-walled smooth hyaline hyphae about 4 μ thick (see Kühner).

Habitat. — On needles, mostly of Picea (*P. excelsa* and *P. orientalis*) in Europe and the Caucasus and on débris of Thuja in California. Gregarious, often two, rarely more, carpophores connected, often in circles. August to November and in California also in the winter.

Material studied. — Fresh material from the locality where Kühner and Maire obtained the specimens for their descriptions cited above: Forêt de Fontainebleau, coll. and det. Singer, Sept., 1935. Dried specimens from the Caucasian Reservation, Malaya Laba Valley, coll. Vassilieva, det. Singer (LE); from Mordovski Reservation, coll. Kuznetsov, det. Singer, preserved at the Reservation; from California, coll. Silva, det. E. E. Morse (NY).

Observations. — This variety differs from var. *lentus* in the consistently larger size of all parts and in both the shape and the surface characters of the stipe.

Leucopaxillus albissimus var. *paradoxus* f. **albiformis** (Murr.), comb. nov.

Clitocybe albiformis Murr., Mycologia, 5 : 211. 1913.
Clitocybe stipitata Murr., Mycologia, 5 : 206. 1913.

Illustrations: Plates III–IV. For the spores see Figure 2 (p. 100).

Pileus (55) 65–150 (300) mm. broad, convex to broadly convex with an involute margin, becoming obtuse or plane, the margin finally spreading or recurved and wavy and more often ribbed than smooth, surface dry and unpolished, appearing matted-fibrillose under a lens, chalk-white when young, gradually becoming yellowish from the center outward, finally "cream buff" (R.) on the disc and "cartridge buff" (R.) toward the margin; flesh white, thick (20 mm. at the stipe in large caps), firm or becoming soft, odor faintly fragrant or pungent and reminding one somewhat of *Tricholoma sulphureum*, taste mild; lamellae pure white to "tilleul buff" (R.), crowded (100–120), many-forked near the stipe, separable from the context of the pileus, narrow to moderately broad (6–8 mm.), narrowed to the cap margin but nearly equal in width most of the distance, unequally decurrent and soon developing decurrent lines, with even

but often undulating edges, decurrent lines on stipe occasionally anastomosing, lamellulae abruptly rounded; stipe (60) 80–150 (200) mm. long, (10) 15–20 (40) mm. thick, nearly equal to decidedly ventricose in lower part, almost always tapered to a pointed base, covered by a mat of débris held together by a copious mycelium, solid, white throughout or surface cream-color to pale buff, pruinose-scurfy to pubescent above or rather evenly covered by minute innate squamules, fibrillose-scurfy or at times even lacerate-scaly in age.

Spores white in mass, 5.8-8 × 3.5 5 μ, hyaline, with strongly amyloid warts, ellipsoid, thin-walled; basidia 27–30 × 6–8 μ, four-spored; cystidia and cheilocystidia none; gill trama subregular; trama of pileus homogeneous, clamp connections present on the hyphae.

Habitat. — On needles and around old conifer stumps under conifers, very often under cedar and fir. Gregarious to subcespitose. Autumn and, in California, winter.

Distribution. — Washington, Oregon, and California.

Material studied. — Type material of *Clitocybe stipitata* Murr. from Stanford University, California (NY); type material of *Clitocybe albiformis* Murr. from Searsville Lake, California (NY). Fresh material from Trinidad, California, H. E. Parks and A. H. Smith no. 3626 (Mich.); A. H. Smith no. 9278, Oregon; 8513, 8712, and 8791, California; T. T. McCabe, Feb. 1, 1938, California, comm. E. E. Morse (Mich.); A. H. Smith no. 17391, Washington (Mich.). Dried material from Bremerton, Washington, 1932, coll. J. B. Flett, det. E. E. Morse (FH); from Seattle, Washington, coll. and det. Zeller (NY).

Observations. — This form differs from f. *eu-paradoxus* in the yellower lamellae of the dried specimens and the more consistently fusoid stipe.

KEY TO VARIETIES AND FORMS OF *L. ALBISSIMUS*

A. Taste bitter or farinaceous-bitterish (American plants)
   1. Color pure white in either fresh or dried condition (if properly prepared). In mixed forests, rarely in pure stands ..... var. *typicus*
   2. Older or dried specimens, buff to tan at least in places
      a) Occurring only in frondose woods. Lamellae not deeply decurrent by ridges or lines. Mycelium soft, silky, copious, pure white. Pileus slightly pubescent when young ..... var. *subhirtus*
      b) Nearly always under conifers or in mixed forests. Lamellae mostly with anastomosing lines or ridges on the apex of the stipe. Base

of stipe strigose or coarsely fibrillose with concolorous fibrils. Pileus almost glabrous ..... var. *piceinus*

B. Taste mild or sometimes somewhat disagreeable
1. In frondose woods. Pileus either decidedly infundibuliform and somewhat hairy-pubescent or subviscid when young and fresh
a) Pileus glabrous, subviscid. In northern Africa and possibly Spain var. *barbarus*
b) Pileus somewhat hairy pubescent, decidedly infundibuliform at least in age. Michigan ..... var. *Kauffmanii*
2. In coniferous woods. Pileus mostly only thinly fibrillose and not distinctly infundibuliform, surface perfectly dry
a) Stipe glabrous in the midportion, 30–60 × 8–15 mm. On needle beds under conifers (Picea, Abies, and Pseudotsuga). Northern Europe and the State of Washington ..... var. *lentus*
1) Stature of a Tricholoma ..... f. *typicus*
2) Stature of a Clitocybe
(a) Few lamellae forked ..... f. *olympianus*
(b) Many lamellae forked ..... f. *furcatus*
b) Stipe not glabrous over the midportion ..... var. *paradoxus*
1) Lamellae white or whitish in dried plants if properly prepared. Stipe subfusoid, 30–80 × 8–25 mm. Southern and eastern Europe and the Caucasus, also in California ..... f. *typicus*
2) Lamellae yellowish in dried specimens, stipe 60–200 × 15–20 (30) mm. Western United States ..... f. *albiformis*

5. **Leucopaxillus nauseosodulcis** (Karst.) S. & S., comb. nov.

Clitocybe nauseosodulcis Karsten, Hedwigia, 12: 177. 1883.
Pleurotus nauseosodulcis Saccardo, Syll. Fung., 5: 448. 1887.

Illustration: Karsten, Icones Selectae Hymenomycetum Fenniae, fig. 23. 1883.
Exsiccati: Karsten, Finland Fungi.

Pileus 50–250 mm. broad, convex then plane, smooth, glabrous, the thin margin irregular and unequal, alutaceous throughout; context thick and soft, odor weak but disagreeable (very fetid in the partly dried plant), taste sweetish but nauseous; lamellae pale, linear, crowded, rather broad (10–15 mm.); stipe 40–140 mm. long, 10–50 mm. thick, solid, eccentric or rarely central, whitish, tomentose but becoming glabrous.

Spores 7–7.5 (8) × 5.3–5.5 μ, hyaline, with strongly amyloid warts, short-ellipsoid to almost ovoid; basidia 35–36 × 6–7 μ; sterigmata 4 μ long; pleurocystidia and cheilocystidia not seen; gill trama subregular, consisting of cylindric, thin (2–3 μ near the subhymenium), nonamyloid hyphae with clamp connections; no lactiferous hyphae seen; hyphae of the cuticle of the pileus very interwoven, smooth, often about 5 μ thick, septate, and nearly always with clamp connections.

Habitat. — On anthills. Connate-cespitose, rarely singly. September.

Distribution. — Finland.

Material studied. — Karsten, Finland Fungi, *Clitocybe nauseosodulcis* (NY).

Observations. — Karsten considered his species to be related to *Pleurotus sapidus*, a true Pleurotus, but Pilát (10) notes that it hardly belongs in that genus. Our investigations on the authentic material preserved at the New York Botanical Garden prove it to be a Leucopaxillus instead. It is close to *L. albissimus*, but is easy to distinguish by its eccentric stipe, its taste and odor, and possibly by the peculiar habitat. The description above is made up from a translation of the original description and Singer's notes based on his study of the exsiccatus.

6. **Leucopaxillus pulcherrimus** (Peck) S. & S., comb. nov.

Clitocybe pulcherrima Peck, Journ. Myc., 14: 1. 1908.

Illustration: For the spores see Figure 6 (p. 100).

Pileus 25–50 mm. broad, convex becoming umbilicate or centrally depressed, decurved on the margin, glabrous, lemon yellow; context white, yellowish under the cuticle; lamellae whitish or faintly tinged with yellow, thin, close, arcuate, decurrent; stipe 25–40 mm. long, 6–8 mm. thick, solid above, hollow toward the base, equal or slightly tapering upward, concolorous with or a little paler than the pileus.

Spores 4–5.8 × 3.5–4.5 μ, strongly amyloid, subglobose, warty; basidia 23–32 × 4–7 μ, four-spored; pleurocystidia and cheilocystidia none; gill trama consisting of interwoven, nonamyloid hyphae; cuticle of pileus compact, consisting of thin interwoven hyphae.

Habitat. — Among fallen leaves. September-October.

Distribution. — Michigan.

Material studied. — Part of type (from near Detroit) preserved at the New York Botanical Garden and another part in the Herbarium of the University of Michigan.

Observations. — The description above is based only on Peck's account and notes on the microscopical characters obtained by us from a study of the type. Kauffman (3) is the only other author who has given a description based on fresh material. He states that the

color of the pileus is citron color to cream-color of Saccardo and that it fades. In addition, he described the pileus as slightly silky-tomentose on the disc, the margin as even, the flesh as white or sometimes tinged cream-color, the lamellae as ochraceous yellow, narrow, equally decurrent, subdistant, a few forked and the edges as entire. He described the stipe as silky-tomentose at first, then fibrillose with loose longitudinal fibrils and even. The odor and taste were given as mild. This is apparently a very beautiful species and related in no way to those indicated by Peck (*Clitocybe vernicosa*, *C. veneris*, *C. venustissimus*), but rather to *L. albissimus* and *L. laterarius*. These two are readily distinguished by their different colors.

7. **Leucopaxillus laterarius** (Peck) S. & S., comb. nov.

Agaricus (*Tricholoma*) *laterarius* Peck, Bull. Buffalo Soc. Nat. Sci., 1 (2) : 43. 1873.
Tricholoma laterarium Saccardo, Syll. Fung., 5 : 101. 1887.
Melanoleuca lateraria Murrill, North Am. Flora, 10 (1) : 10. 1914.

Illustrations:
Plate V. For the spores see Figure 1 (p. 100).
M. E. Hard, The Mushroom, Edible and Otherwise. Its Habitat and Its Time of Growth, fig. 47.
Kauffman, Agar. Mich., II, pl. 151 (as *Tricholoma acerbum*).

Pileus (40) 70–120 (200) mm. broad, when young obtuse to broadly convex with an inrolled margin, becoming broadly convex to plane, sometimes obtusely umbonate, surface dry and unpolished, under a lens appearing somewhat matted-fibrillose, in age at times becoming minutely scurfy or with spotlike patches (not true scales) around the disc, the margin frequently ribbed or grooved, entirely white or with a faint flesh-pink tinge (between white and "vinaceous buff" — R.), sometimes creamy yellowish over the disc; context white, thick and firm, unchanging, odor farinaceous and sometimes rather disagreeable, in dried individuals somewhat spicy, taste subastringent to very bitter; lamellae white or pale cream-color in age, narrow, crowded, with entire edges, adnate to sinuate but decurrent by lines which do not anastomose; stipe 40–110 mm. long, 6–20 mm. thick at the apex, solid, very firm, subequal or clavate and 30–40 mm. thick at the base, surface unpolished to minutely pubescent, remaining unpolished in age, white throughout, usually with a mass of white mycelium surrounding the base and penetrating through the adherent leaves.

Spores white in mass, 3.5–5.5 × 3.5–4.7 μ, globose to short-ellipsoid, most frequently subglobose, thin-walled, hyaline, very slightly rough to verrucose, the warts strongly amyloid; basidia 22 31 × 5.5 7 μ; four-spored; pleurocystidia none; cheilocystidia lacking or very scattered, 2–5.5 μ thick; pileus trama homogeneous, its hyphae bearing clamp connections.

Habitat. — In frondose woods, particularly on accumulations of leaves and débris of Quercus and Fagus. Singly to scattered. July-November.

Distribution. — Eastern part of North America from Canada to Florida and west to Michigan.

Material studied. — The type, from Worcester, New York (NYS). Fresh material from Chocorua, New Hampshire, coll. D. H. Linder and R. Singer (FH). Dried material from Ontario, Canada, Bear Island, Lake Timagami, University of Toronto Crypt. Herb. no. 76425, coll. and det. H. S. Jackson (one portion FH); from North Carolina, coll. Totten (det. as *Clitocybe albissima*) (NY); from Ball Camp Pike, Knox Co., Tennessee, coll. and det. L. R. Hesler no. 10924 (FH and Mich.); from Florida, coll. and det. Murrill (as *Tricholoma albissimum floridanum* Murr., part of type?) (FH); from Seventh Lake, Adirondack Mountains, New York, coll. H. M. Fitzpatrick, W. W. Ray, W. L. White, det. H. M. Fitzpatrick (as *Clitocybe candida*) (FH). The following collections are deposited in the University of Michigan Herbarium: L. C. C. Krieger (Kelly Herb. no. 1744), Magnetawan, Ontario, Canada; Kauffman, Ithaca, New York, July 13, 1903; Kauffman, Washtenaw County, Michigan, Oct. 12, 1904; Smith, Ann Arbor, Michigan, July 1, 1929, det. Kauffman (as *Tricholoma acerbum*); Smith, nos. 1413, 1449, and 3979 from Michigan; Stuntz and Smith no. 15165, Oakland County, Michigan, July 2, 1930.

Observations. — In Michigan Smith has observed that during certain seasons small (40 80 mm. broad) white specimens occur, whereas during other seasons one finds large fruiting bodies with cream-colored pilei 100 150 mm. broad. Regardless of whether the pileus is white, cream buff, or the characteristic pale pinkish buff, the small spores are an infallible character. *L. laterarius* is rather common in eastern and east-central North America. The name *Tricholoma acerbum*, which was applied to it by Kauffman and others who followed him, should be discarded in favor of the name

given by Peck to American material. *T. acerbum* sensu Bresadola is a typical Tricholoma, with nonamyloid spores and without clamp connections. *T. acerbum* sensu Lange may be close to Kauffman's concept of that species, but Lange has not given sufficient information to allow one to be certain of the identity. His fungus, to judge from his plate, is more highly colored than the American species, but does have the very small spores. Lange, however, did not give the iodine reactions of the spores of Tricholoma; hence, unless he has preserved his specimens, it will be impossible to determine whether his species is or is not a Leucopaxillus.

8. *Leucopaxillus rhodoleucus* (Romell) Kühner, Bull. Soc. Linn. Lyon, 5 (16) : 125. 1926

Agaricus (*Clitocybe*) *rhodoleucus* Romell, Botan. Notiser for the year 1895 : 66. 1895.
Clitocybe rhodoleuca Saccardo, Syll. Fung., 14 : 74. 1899.
Lepista rhodoleuca Maire, Bull. Soc. Myc. Fr., 40 (4) : 305. 1925.

Illustrations: Maire, *l. c.*, pl. 20, figs. 2–7.

(*a*) *Description of the Swedish plant (from the original by Romell).* — Pileus white in dry weather, pinkish in wet weather, becoming glabrous, fleshy, convex or at last almost plane, very rarely somewhat concave, 20–80 mm. in diameter. Context white, odor weak, taste mild. Lamellae pink or incarnate-pale, in wet weather more intensely colored, almost crowded, narrow (1–5 mm.), some forked, decurrent. Stipe concolorous with the pileus, conic or nearly cylindric from a thickened base, 20–40 × 5–20 mm.

Spores white in mass, 6–9 × 5–6.5 μ, hyaline, slightly rough, obovate; basidia 30–45 × 8–9 μ, four-spored; cystidia none.

Habitat. — On needles under *Picea excelsa*. Gregarious to cespitose. August-November.

(*b*) *Description given by R. Maire.* — Pileus snow-white, then more or less marked with droplike spots or marbled, usually concentrically, by purplish-gray or yellowish-gray hygrophanous spots, with separable moist subviscid cuticle, later dry, glabrous, fleshy, convex then plane and slightly depressed at the center, often more or less wavy, 40–80 mm. in diameter. Context white with a pink reflection in the pileus, purplish gray and hygrophanous next to the lamellae, thick, firm in the pileus, fibrous-fleshy in the stipe, taste mild, rather sweet, odor faint, guaiac negative. Lamellae

pinkish white, especially in the space between the lamellae, becoming whitish, anastomosing at times, crowded, not separable from the context of the pileus, thin, narrow (3–4 mm.), arcuate, attenuate at both ends, deeply decurrent, lamellulae attenuated at inner extremity; stipe white, opaque, glabrous or somewhat furfuraceous-fibrillose at the apex, dry, solid, subcylindric or somewhat enlarged toward the base, confluent with the pileus, 30–40 × 12–23 mm.

Spores pure white in mass, 7–9 × 4.5–5.5 μ, hyaline, warty, amyloid, thin-walled, short ellipsoid-obovate, with one or several droplets; basidia cylindric-subclavate 40–50 × 8–9 μ, four-spored; pleurocystidia none; cheilocystidia none; subhymenium ramose, rather thick (three fourths the thickness of the hymenium); gill trama regular, compact, consisting of rather short cells 6–10 μ thick.

Habitat. — On needles of *Cedrus atlantica.* Gregarious, sometimes two carpophores connate. Autumn.

Distribution. — Sweden, France, and North Africa, according to Maire.

Observations. We have not examined material of this species, which we include on the basis of R. Maire's account, summarized above. The original description and that of Maire are given separately because of some disagreement among European authors over the identity of Romell's species. Bresadola in his *Iconographia*, Vol. 3, pl. 117, stated that he had compared the original material of *Clitocybe rhodoleuca* Romell with his *Tricholoma panaeolum* and found it to be a form of the latter with decurrent lamellae. We do not accept Bresadola's statement as final, however, because it is now known that his *T. panaeolum* is a mixture of two species, *Rhodopaxillus caespitosus* and *R. nimbatus*, both of which have sordid pinkish spore prints. Since Romell was a very accurate observer so far as the exact colors of spore prints were concerned, we do not believe this species had spores that were dirty pinkish in mass, and we therefore accept Maire's account. *L. rhodoleucus* is probably very difficult to distinguish from species of Rhodopaxillus of the section Panaeoli if (like Bresadola) one does not know one of them to begin with and if one does not use the iodine reaction of the spores, a character also not employed by Bresadola. *L. rhodoleucus* must resemble *Clitopilus prunulus* so far as its macroscopical appearance is concerned. It differs from other Eu-Leucopaxilli in having attenuated lamellulae, hygrophanous spots, and pinkish lamellae in-

separable from the hymenophore as well as a comparatively thick subhymenium.

9. *Leucopaxillus tricolor* (Peck) Kühner, Contrib., p. 135. 1926.

Tricholoma tricolor Peck, Ann. Rep. New York State Mus., 41 : 60. 1888.
Melanoleuca tricolor Murrill, North Am. Flora, 10 (1) : 17. 1914.
Tricholoma pseudoacerbum Cost. & Duf., Prem. Suppl. Nouv. Flor. Champ., p. 259. 1896.
Leucopaxillus pseudoacerbus Boursier, Bull. Soc. Myc. Fr., 41 : 392. 1925.
Lepista pseudoacerba Konrad & Maublanc, Icon. Sel. Fung., 6 : 350. 1937.

Illustrations:
Plate VI. For the spores see Figure 4 (p. 100).
Kauffman, Agar. Mich., II, pl. 155. 1918 (as *Clitocybe maxima*).

Description of the American type. — Pileus 90–300 mm. broad, convex to plane or with a broad low obtuse umbo, the margin strongly inrolled, sometimes slightly depressed in the center (scarcely subinfundibuliform in age — Kauff.) surface dry, unpolished and matted-fibrillose (more or less like felt), opaque at all stages, margin furrowed or grooved, color pale alutaceous inclining to russet (see Peck) ("pinkish buff" at first, soon darker and dull tan over the disc — Smith), becoming darker as it ages or dries ("vinaceous," "deep vinaceous," "dark vinaceous," "hydrangea red," or "mineral red" in dried plants — Singer); flesh very thick and firm but becoming thinner and flabby in very old individuals, white or whitish, odor and taste pungent to farinaceous, rather strong and disagreeable (taste mild — Kauff.; odor like that of *Agaricus campestris* — Ellis); lamellae close to crowded, readily separable from the pileus, "marguerite yellow" (pale clear yellow) in fresh young plants (whitish — Kauff.), becoming darker yellow in age, and when dried becoming dark reddish or purplish (the color very distinctive), narrow to broad, broadest in old specimens; stipe 40–60 (100) mm. long, 10–30 mm. thick at apex, sometimes 40 mm. at the base, tapering or equal upward from a thickened or abruptly bulbous base, solid and fleshy, white within, surface whitish and unpolished or with a thin cottony-tomentose covering (often stained ferruginous . . . the bulb at length the color of the pileus — Kauff.).

Spores white in mass, 6–8 × 4–5.5 μ, hyaline, shortly ellipsoid, with a slight depression, thin-walled, oil drop medium-sized, surface covered with distinct isolated strongly amyloid warts; basidia 26.5–

30 × 6.7–7 (9) μ, four-spored; pleurocystidia none; cheilocystidia usually present but rare, scattered among the basidia; subhymenium thin and ramose; gill trama subregular; the whole hymenium covered with a lilac amorphous granular mass in dried specimens.

Habitat. — In frondose woods, usually under Quercus. Singly, scattered, gregarious, or subcespitose. July-October.

Distribution. — Eastern United States.

Material studied. — The type from Selkirk, New York (NYS). Authentic material from Round Lake and South Ballston, New York (typical) (NY). Fresh material from Oakland County, Michigan, coll. and det. Smith, nos. 6897, 6954, 7052, 7269, 7304, 10993, 15464 (Mich.). Dried specimens from New Jersey collected by Ellis, who considered it representative of a new species (FH); from Auburn, Alabama, coll. C. F. Baker (FH); Kauffman's Michigan collections, numbering four, determined as *Clitocybe maxima* (Mich.).

Observations. — This species has the appearance of a large Tricholoma, and is unmistakable in the dried condition. Kauffman in his *Agaricaceae of Michigan*, p. 721, described it in detail under the name *Clitocybe maxima* Fr. and then merely quoted Peck's description for *Tricholoma tricolor*. His description and comments, so far as they apply to the material he studied, are excellent, but his remarks about the relationships of the species should be disregarded. From the studies of Kauffman and of Smith on Michigan specimens it is evident that the color of the gills is a somewhat variable character, and that the differences noted in the existing descriptions are best interpreted as various stages in the change of color that takes place as the fruiting bodies mature and age. Hence the degree of yellowness of the gills of a particular collection is of no significance taxonomically. The taste also appears to be variable. Smith noted it as given above (disagreeable). Singer found the taste of dried specimens slightly bitter. The taste of European and also Kauffman's specimens has been described as mild. Consequently it does not seem possible to distinguish European from American specimens on the basis of either character. In order to enable anyone to compare his collections with European as well as American descriptions we give the following translation from Kühner (5).

Pileus light buff, light flesh-colored-alutaceous in the center with paler cream-colored to pale sulphur-cream-color at the tomentose margin, surface punctate or like a cobweb, sometimes areolate

in the center, strongly convex with more or less ribbed margin which expands only in age, 130–160 mm. in diameter. Lamellae distinctly yellow sulphur-cream-color, crowded (120 ±, 5 tiers of lamellulae), nondecurrent but also not distinctly sinuate. Spore print white. Spores 7.5 × 4.5–5 μ, warty, amyloid, ellipsoid. Basidia 48 × 9–10 μ, four-spored. Hyphae of the rather regular dense trama 6–8 μ in diameter. Subhymenium ramose, hardly distinct from the trama. Stipe white or cream-color, the base sometimes sulphur-colored; solid, 28–36 mm. thick, thickened downward into a sometimes marginate bulb, 40 × 20 mm. Context white, thick and compact; odor not very agreeable, virose, herbaceous, or of fresh wood (the same comparison was used by Kühner for the odor of *L. albissimus* var. *paradoxus*). Taste sweetish, somewhat like that of sugar. Hyphae very interwoven, 6–10 μ broad, with clamp connections.

Habitat. — In woods (under frondose trees in September, according to Singer).

Distribution. — France.

Material studied. — Fresh specimens from Forêt de Fontainebleau, France, coll. and det. Singer.

Observations. — Singer's specimens were from the same locality from which Kühner obtained his, and were found to be identical with Kühner's in all respects. These European collections differ from American specimens in the more pronounced yellow color of the margin of the pileus and the stipe, possibly in odor, although this character is difficult to compare, and in the sweetish taste, a character of doubtful value in this instance. Boursier published a second description, which differs from the one above in a few points: pileus smooth, sometimes subtomentose, up to 200 mm. broad, pale brown ("café au lait"). Lamellae lemon yellow becoming dark violet in the herbarium, rather thick, almost free. Spores 8 × 5.5 μ. Basidia 27 × 8 μ. Subhymenium broad. Trama very broad, almost interwoven. Cuticle of thin-appressed fibrils. Stipe white, smooth, 60 × 30 mm. Context mild. In frondose woods in the grass. July-September. S. Buchet and H. Colin (2) published an interesting study on *Tricholoma pseudoacerbum* as early as 1913. They showed that the pigment of this species colors alcohol and ether a gooseberry pink, the etheric solution showing a blue fluorescence. In concentrating the solutions they obtained finally a dark brown resinaceous product. *T. acerbum* gave a very different reaction.

10. **Leucopaxillus brasiliensis** (Rick) S. & S., comb. nov.

Tricholoma brasiliense Rick, Brotéria, 6 : 72. 1907.

Illustrations: Rick, *l. c.*, pl. 9, fig. 7 (photographs).

Pileus 40 mm. in diameter, slightly depressed when expanded, submembranaceous at the involute margin, varnished-glabrous, dark violet, ashy green around the margin; flesh fuliginous, reddening, firm, odor farinaceous; lamellae bright yellow orange, crowded, narrow, unequal, forked toward the margin, subsinuate with a decurrent tooth, becoming dark vinaceous in dried condition; stipe 50 mm. long, 10 mm. thick, fleshy, solid, slightly thickened into the pileus, fuliginous-chestnut, gray-powdery toward the pileus, greenish tomentose from the mycelium toward the base, reddening in drying.

Spore print white ("sporis albis" — Rick); spores 5×3.2–4 μ, hyaline, shortly ellipsoid to globose, without hilar depression, warty, strongly amyloid; basidia 20–27×5–7 μ; cheilocystidia rather numerous in places (but an abundant dark vinaceous incrustation hindered exact observation, and it cannot be stated to what extent the edge is heteromorphous); gill trama subregular, consisting of interwoven rather narrow hyphae; hyphae of the flesh of the pileus with clamp connections.

Habitat. — In woods on the ground (among leaves).

Distribution. — Brazil.

Material studied. — Authentic material (part of type?) in the Patouillard Herbarium (FH).

Observations. — *L. brasiliensis* is related to *L. tricolor* by the shape and color of the lamellae in the fresh and dried condition, but differs in its smaller size, the color of the living fungus, and the smaller spores. The description above is made up from Rick's original account and our notes on the dried specimens.

11. *Leucopaxillus amarus* (Å. & S.) Kühner, Ann. Soc. Linn. Lyon, 73 : 84. 1927.

Agaricus rivulosus ββ amarus Albertini & Schweinitz, Consp. Fung. Lusat. p. 185. 1805.
Agaricus amarus Fries, Syst. Myc., 1 : 87. 1821.
Clitocybe amara Quélet, Champ. Jura et Vosges, 1 : 234. 1872.
Omphalia amara Quélet, Enchir. Fung., p. 21. 1886.
Gyrophila amara Quélet, Flore Myc., p. 283. 1888.
Tricholoma amarum Rea, Brit. Bas., p. 221. 1922.

Lepista amara R. Maire *in litt.* apud Konrad et Maublanc, Icon. Sel. Fung., 4, pl. 300.
Clitocybe gentianea Quélet, Champ. Jura et Vosges, 2: 341. 1873.
Omphalia amara var. *gentianea* Quélet, Enchir. Fung., p. 21. 1886.
Agaricus vulpeculus Kalchbrenner apud Fries, Hymen. Eur., p. 83. 1874. Romell, Botan. Notiser for the year 1895: 67. 1895.
Clitocybe vulpecula Saccardo, Syll. Fung., 5: 149. 1887.
Agaricus conspicuus Lasch, Linnaea, 4: 522. 1829.
Agaricus miculatus Secr., Mycogr. Suisse, 2: 163. 1833.
Melanoleuca bicolor Murrill, Mycologia, 5: 215. 1913.
Tricholoma bicolor Murrill, Mycologia, 5: 223. 1913.
Melanoleuca roseibrunnea Murrill, Mycologia, 5: 220. 1913.
Tricholoma roseibrunneum Murrill, Mycologia, 5: 223. 1913.

Illustrations:
For the spores see Figure 5 and for the hyphae of the cuticle see Figure 7 (both figures on page 100).
Barla, Champ. Alp. Mar., pl. 50, figs. 1–9.
Cooke, Illus., pl. 132A (134A).
Lanzi, Fung. Roma, pl. 131, fig. 1.
Quélet, Champ. Jura et Vosges, 2, pl. 1, fig. 5.
Kalchbrenner, Icon. Sel. Hymenomycetum Hungariae, Fasc. 4, pl. 39, fig. 2.
Bresadola, Icon. Myc., 3, pl. 138.
Konrad et Maublanc, Icon. Sel. Fung., pl. 300.
Kühner, Bull. Soc. Myc. Fr., Atlas, pl. 24. (Supplement to Tome 44. 1928) (very good).
Lange, Flora Agar. Danica, 1, pl. 24, fig. D (very good).
Kauffman, Pap. Mich. Acad. Sci., Arts, and Letters, 8, pl. 8 (photograph).
(The figures of Patouillard, Eloffe, and Britzelmayr are either wrong or poorly executed.)

In the following treatment we have divided the species into five forms, which are keyed out on pages 130 and 131.

F. *typicus*. Plate VII.

Pileus 40-80 120 (150) mm. broad, convex or very rarely obtusely umbonate, eventually more or less flattened or the disc depressed, the margin involute and sulcate at first, spreading or wavy and grooved in age, surface dry and subtomentose at first, sometimes becoming more or less glabrous, sometimes more or less subsquamulose, in age at times verruculose-areolate to subrimose, color "liver brown," "chocolate," or "Verona brown" (R.) (deep reddish brown) when young, becoming paler reddish brown at maturity or in age (between "chestnut" and "mahogany red," "tawny," or "ochraceous tawny" — R.), frequently with a much paler margin ("tilleul buff "— R.), dried specimens often between "russet" and "fawn color" (R.); context white, rather thick and firm, odor peculiar,

either strong or very faint and resembling that of *Tricholoma sulphureum* but more farinaceous; taste bitter; lamellae white, finally cream-white and then at times with ferruginous spots, narrow (3–8 mm.), close (85–110), adnate and more or less sinuate but frequently with prolonged ribs extending down the apex of the stipe, separable from the context of the pileus; stipe 40–60 mm. long, 8–45 mm. thick, equal to bulbous, solid or becoming hollowed, pure white or the base becoming sordid-brownish in age where touched, apex faintly pruinose, sometimes minutely pubescent over all.

Spore print pure white; spores 4.3–6 × 3.7–5 μ, subglobose, with little or no depression, with distinct isolated strongly amyloid warts, thin-walled, contents with one oil drop; basidia 27–33 × 6–7.5 μ, four-spored, sometimes with a few two-spored individuals intermixed; pleurocystidia none; cheilocystidia very abundant, with only scattered basidia among them, variable in shape, fusoid, clavate-cylindric or bottle-shaped, never thickened at the base, sometimes forked or variously branched, 25–38 × 2–6.5 μ; subhymenium ramose, thin; trama subregular, the hyphae 1–3 μ thick, progressively more interwoven toward the midportion of the gills and also toward the flesh of the pileus; hyphae of the flesh of the pileus with clamp connections; hyphae of the cuticle reddish brown inside from a dissolved pigment and, in addition, the walls covered by an abundant rufous-brown pigment incrusting the walls in the form of warts or rings or irregular plates. (The hyphae are thin-walled or part of them have moderately thickened walls. The cuticle is very dense.)

Habitat. — Mostly in coniferous woods (Pinus, Abies, Pseudotsuga, Larix), in southern regions also under species of Quercus. Mostly gregarious. July to November or occasionally in January.

Distribution. — Europe, Caucasus, North Africa, United States (California, Idaho, Washington, and Wyoming). If the other forms are included the distribution is extended to Colorado and also South Africa.

Material studied. — Fresh specimens from: the Nakra Valley, Svanetia, Central Caucasus, coll. and det. Singer (Herb. Naturhist. Mus. Vienna); Idaho, Smith no. 15870, and Washington no. 3178 (Mich.). Dried specimens from: Sweden, coll. and det. L. Romell (NY), California (in oak woods) det. Murrill as "*Trich. bicolor*, not typical" (NY); California, coll. Copeland, det. Morse and Mentzer as *Melanoleuca roseibrunnea* (Morse, Fungi of the Pacific Coast no.

100) (FH); California, coll. Copeland, Sept. 18, 1936 (Mich.); Wyoming, coll. Kauffman and Kanouse, det. Kauff. (Mich.).

The typical form could be further divided into a small and a large race: the first with the pileus usually less than 80 mm., the stipe narrower than 14 mm., odor constantly strong; the second with the cap usually over 80 mm. at maturity, and the base of the stipe over 14 mm. if bulbous. The latter is sometimes odorless. The specimens of Fries, Lange, and Romell belong to the smaller race. Singer's Caucasian material, Smith's Idaho collection, and certain of Murrill's and Morse's collections from the Pacific coast belong to the larger race. For those who insist on some designation for these units we suggest the names *L. amarus* f. *typicus* sf. *minor* and sf. *major*.

F. **vulpeculus** (Kalchb.) S. & S., comb. nov.

F. *vulpeculus* differs only slightly from f. *typicus* sf. *major*. It can be distinguished by its mild taste and, according to Kühner's description (his plate and description belong here), by the cheilocystidia, which are enlarged (up to 11 μ at the base). We doubt, however, whether there is really a constant difference in the shape of those organs. F. *vulpeculus* is met with chiefly in larch forests in the mountains (the Alps and the Carpathian Mountains). Romell, however, seems to have observed the same form in spruce woods.

F. **roseibrunneus** (Murr.) S. & S., comb. nov. Plate VIII

Pileus 30–140 mm. broad, broadly convex but often irregular from crowding, rarely somewhat gibbous when young, later nearly plane and the margin inrolled, surface dry and unpolished (plush-like) when young, appearing fibrillose under a lens, somewhat cottony-tomentose along the margin, in age expanded and somewhat scurfy at times, sometimes irregularly rimose and sometimes breaking up into fine scales over all except the disc, the margin spreading and ribbed or almost smooth, color dark to pale reddish brown on the disc, buff to alutaceous along the margin ("pecan brown," "russet," or "Mars brown" on disc, toward the margin "avellaneous," "wood brown," or "pinkish buff" — R.), in dry weather the color sometimes duller owing to a hoary coating, or mottled with brownish circular spots; context white, unchanging when bruised, firm and hard in the stipe, thick and tapering evenly but sharply toward the margin of

the pileus, odor faintly farinaceous to strongly rancid-farinaceous, taste bitterish to somewhat farinaceous, strong at times; lamellae milk-white to nearly pure white, not staining readily when bruised but sometimes slightly sordid in age, narrow to moderately broad (3–10 mm.), close to crowded (82–120 mm.), thin, 2–4 tiers of short individuals, edges even or slightly eroded, adnate or narrowly adnexed, frequently developing a decurrent tooth; lamellulae abruptly rounded to emarginate; stipe white, rarely buff in age, solid but frequently becoming hollow, unpolished to subtomentose or almost scabrous, somewhat glabrescent in age, base surrounded by a mat of fine white mycelial or rhizomorph-like fibrils that hold the débris together, clavate or with an enlarged bulbous base, later often becoming equal, 20–100 × 9–50 mm.

Spores white in mass, 5–7 × (3.5)4–5 μ, hyaline, with strongly amyloid warts and little or no depression, short-ellipsoid to subglobose; basidia 31–38 × 6–8.3 μ, four-spored; pleurocystidia none; cheilocystidia cylindric, subfusoid or fusoid, some forked, rarely clavate, more frequently flask-shaped, thin-walled, hyaline, smooth, 20–45 × 2–5.5 μ, mostly 26–28 × 3.3–3.5 μ (if flask-shaped or subulate, base up to 5.5 μ, apex about 2 μ in diameter), often wavy and flexuous; subhymenium ramose, thin; gill trama subregular, dense, consisting of interwoven hyphae about 2.5 μ thick or larger in the central portion; flesh of pileus evenly filamentose, the hyphae with clamp connections; hyphae of the cuticle distinctly colored by a reddish-brown dissolved intracellular pigment, with rather distinct but rare incrustations of a reddish-brown to dark-brown (in some places hyaline) intercellular pigment that forms but faint low markings on the thin or rather thin walls, the hyphae (2)5(8) μ thick, the cuticle very dense.

Habitat. — In coniferous woods on needles (Abies, Pseudotsuga, Thuja, Picea) and especially in places where *Alnus rubra* is also present, in pure stands of which it often occurs in great quantities. Under oak it is met with more rarely. Gregarious to cespitose and often in arcs or rings. July-December.

Distribution. — Western part of North America: Washington, Oregon, California, Idaho, Wyoming. Possibly also in Europe and Africa.

Material studied. Type material of *Melanoleuca roscibrunnea* from Seattle, Washington (NY). Numerous fresh collections of A. H. Smith, nos. 2486, 2557, 2569, 3150, 3308, 3877, 7803, 8067,

8201, 9277, 14814, 17024, 17358, 17404, 17561, 17932 (Mich.). Kauffman's material from Wyoming, Sept. 10, 1923, and from Oregon (Takilma and Mt. Hood) (Mich.), Epling no. 146, det. as *Tricholoma acerbum* (Mich.). One collection from Calistoga, California, coll. Curtis Wright, det. E. E. Morse (FH).

Observations. — This is the most frequent form in America. Like f. *typicus*, it can be divided into a large robust and a smaller slender subform, sf. *majusculus* and sf. *subminutus*.

F. **bicolor** (Murr.) S. & S., comb. nov.

Distinguished from the preceding form in having none or only a very little incrusting pigment on the hyphal walls, and very little intracellular pigment. The pileus is avellaneous with a pink tint. The width of the pileus is 60–120 mm. (according to Murrill). The cuticle of the pileus is dense, consisting of interwoven nonincrusted hyphae 2.5–8 μ (mostly 4–6 μ) thick. Spores 5–6.5 (7.5) $\times$ 4–5 μ, hyaline, short-ellipsoid to subglobose, thin-walled, without a depression, with 0–1 oil drop, with strongly amyloid warts. Basidia 26–40 $\times$ 6–9 μ, four-spored. Sterigmata 3.5 μ long. Pleurocystidia none. Cheilocystidia 20–35 $\times$ 2–5 μ, numerous but scattered between fertile basidia, cylindric, rarely clavate. Gill trama subregular, browner than the basidia in iodine but not amyloid, compact. Stipe 50–60 $\times$ 10 mm. $\pm$ (according to Murrill). In a dense fir forest with few old oak trees, 400 to 1000 feet elevation; also on needles (trees and elevation not determined).

This form was found in the same area as the preceding, but possibly in drier situations. It is known from Washington and California. Murrill stressed the white color of the lamellae in dried material as a distinguishing character. A great deal seems to depend, however, on how the specimens were prepared, and we doubt whether this distinction is a good one. We saw two collections, the type with whitish lamellae (NY) and one with yellowish-buff lamellae, from Pike's National Forest, Colorado (NY), which had been determined as *Clitocybe piceina*.

F. **alboalutaceus** (F. H. Møller apud Lange as Tricholoma) S. & S., comb. nov.

F. *alboalutaceus* has been found in Denmark and is said to be white (in age somewhat alutaceous). We have not studied the ma-

terial. Since F. H. Møller was the collector of Lange's material of *L. amarus* f. *typicus* he must have known this species, and therefore we are inclined to believe that var. *alboalutaceus* is nothing more than a very pale form of *L. amarus*.

Var. *gracilis* Kalchbrenner (as Agaricus) in de Thümen, Mycotheca Universalis, no. 702

This plant was collected in Somerset East near the Cape of Good Hope in South Africa on leaves (not needles) by MacOwan and Tuck. Since the edges of the lamellae are decidedly agglutinated it is rather difficult to distinguish cheilocystidia on the specimens examined (FH). The general impression is that of a slender *L. amarus*, and the characters all conform with this identification. Since the hyphae of the pileus cuticle are smooth and not incrusted (in either NH_3 or water) and are 2–5 (9) μ thick, var. *gracilis* comes nearest to f. *bicolor*. The spores were found to be warty and strongly amyloid, with only a slight depression, short-ellipsoid, 4–5.2 $\times$ 3–4 μ. The basidia are 21.5–27.5 $\times$ 5.5 μ. The gill trama is subregular. At least a few cheilocystidia are present, and the color of the cap is more or less as in *L. amarus* f. *roseibrunneus* or f. *bicolor*. The pileus measures about 40 mm.; the stipe, about 50 $\times$ 4 mm., but is thicker at the base. The lamellae are narrow and crowded. Since we do not believe that Kalchbrenner's variety deserves the same rank as the varieties of *L. albissimus*, we propose the name *L. amarus* f. **gracilis** (Kalch.) S. & S., comb. nov.

KEY TO FORMS AND SUBFORMS OF *L. AMARUS*

A. Well-pigmented forms (i.e. either incrusting intercellular pigment or dissolved intracellular pigment or both abundant)
  1. Incrusting pigment very distinct and abundant. Color of pileus dark (see description)
    a) Context with a bitter taste ..... f. *typicus*
      (1) Pileus smaller than 80 mm.; stipe narrower than 14 mm. sf. *minor*
      (2) Pileus frequently or always larger than 80 mm. and base of stipe thicker than 14 mm. when it is bulbous ..... sf. *major*
    b) Context mild ..... f. *vulpeculus*
  2. Incrusting pigment rather scarce but rather distinct. Color of the pileus generally dull (see description) and produced by a dissolved intracellular portion of the pigment ..... f. *roseibrunneus*
    a) Pileus smaller than 80 mm.; stipe narrower than 14 mm. sf. *subminutus*
    b) Pileus frequently or always larger than 80 mm. and base thicker than 14 mm. when bulbous ..... sf. *majusculus*

B. Faintly or almost nonpigmented forms. Most of all hyphae of cuticle seem to be hyaline in an ammonia medium under high magnification; incrusting pigment practically none
1. On needles of conifers. Stipe about 10 mm. thick or thicker. Occurring in Northern Hemisphere
a) Albino form, found in Europe ..... f. *alboalutaceus*
b) Colored form, found in the western part of North America f. *bicolor*
2. On leaves of deciduous trees. Stipe thinner than indicated above. From Southern Hemisphere ..... f. *gracilis*

12. **Leucopaxillus gracillimus** S. & S., sp. nov.

Pileo sanguineo, glabro, subapplanato, umbonato, tenui, 35–50 mm. lato. Hyphis cuticulae haud incrustatis pigmento. Lamellis pallidis, confertissimis, angustissimis, decurrentibus. Sporis 3–5.5 × 2.2–4 μ, hyalinis, subglobosis, verrucosis, amyloideis. Stipite albo, subaequali, glabro, gracili, 45–55 × 2 mm. Carne alba, tenui. Habitat in terra, São Leopoldo, Rio Grande do Sul, Brasilia.

Pileus 20–50 mm. broad, almost flat and often umbonate, the margin incurved, glabrous, color blood red when fresh, reddish brown (almost the color of *L. amarus* f. *typicus*) when old, rather uniformly colored over all when dried; flesh white, thin in pileus and stipe, odor and taste unknown; lamellae very pale buff, probably white in fresh condition, extremely close and very narrow (reminding one of *Lentinus crinitus*), decurrent; stipe evidently white in fresh condition, nearly equal or ventricose in the lower half, 25–55 × 2–5 mm. in the dried condition, with a white mycelium at the base.

Spores 3–5.5 × 2.2–4 μ, mostly 4.7 × 3.8 μ, hyaline, short-ellipsoid to globose, without a hilar depression, warty, strongly amyloid; basidia 23 24 × 5.5–6.5 μ, four-spored; cheilocystidia 21–25 × 1.7–7 μ, filamentose, flexuous, frequently more or less thickened at the base, abundant and rendering large areas along the gill edges heteromorphous; pleurocystidia none; gill trama rather regular, no lactifers seen; hyphae in flesh of pileus with clamp connections.

Habitat. — On the ground.

Distribution. — Brazil, Province Rio Grande do Sul.

Material studied. — Dried specimens from São Leopoldo, coll. and det. (as *Clitocybe paropsis*), in 1930, Steffen, comm. Rick (FH); dried material from São Leopoldo, coll., det., and comm. Rick (1931) (FH); São Canisio do Porto Novo, Sta. Catharina, coll. Rick, 1928 (FH).

Observations. — This species seems to be rather near *L. amarus* f. *gracilis*, but when compared with it is obviously distinct because of its blood-red pileus, more slender stature, closer and narrower lamellae. The Brazilian species has nothing in common with *Clitocybe paropsis* of Europe and therefore must be described as new.

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Leuco paxillus albissimus var. *lentus* f. *typicus* (Rom.) S. & S. × 1

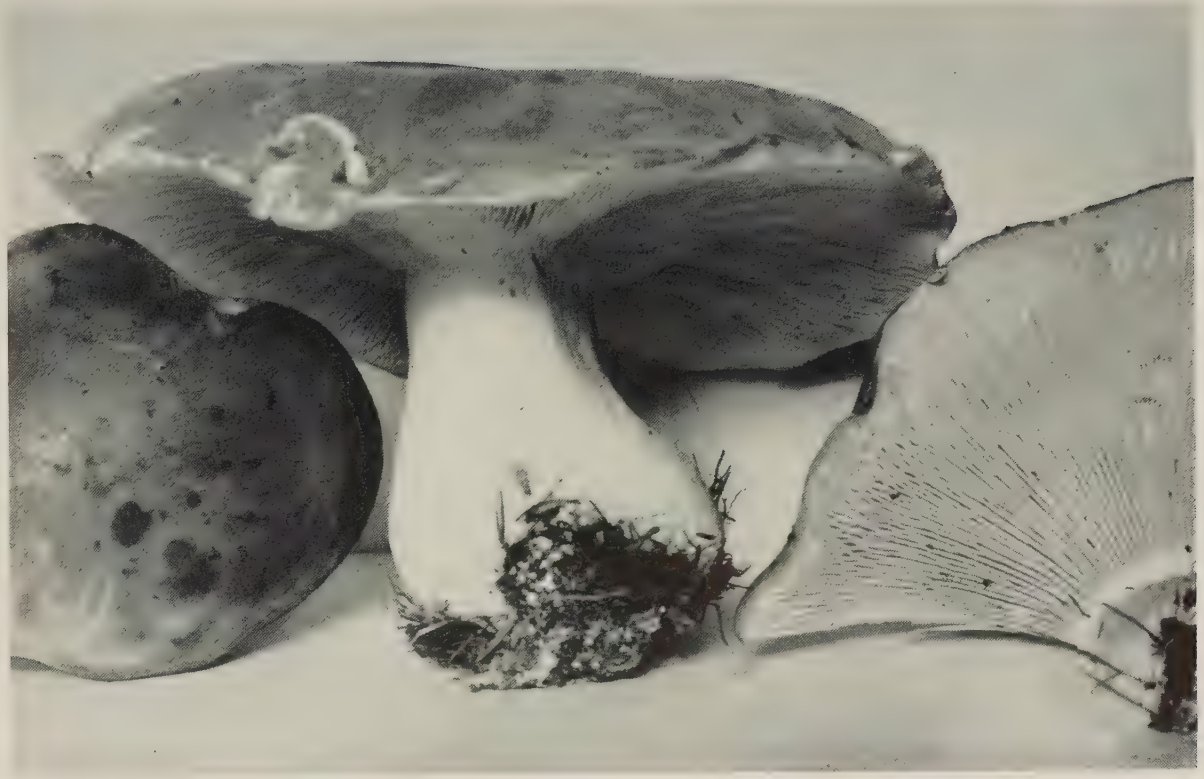
Leucopaxillus albissimus var. *lentus* f. *olympianus* S. & S. × 1

Leucopaxillus albissimus var. *paradoxus* f. *albiformis* (Murr.) S. & S. × 1

Leucopaxillus albissimus var. *paradoxus* f. *albiformis* (Murr.) S. & S. × ½

Leucopaxillus laterarius (Peck) S. & S. × 1

Leucopaxillus tricolor (Peck) Kühner. × 1



Leucopaxillus amarus f. *typicus* sf. *major* S. & S. × 1

Leucopaxillus amarus f. *roseibrunneus* sf. *subminutus* S. & S. × 1

DIFFERENCES IN MEIOTIC COILING BETWEEN TRILLIUM AND TRADESCANTIA

CARL P. SWANSON

THE recent reviews by Nebel (1941) and Huskins (1941) of chromosome structure and coiling are indicative of the considerable research that has been done in this special field of cytology. Nebel has stressed, in particular, the interpretation of the images obtained at the lower limits of resolution as well as the hazards involved; Huskins, on the other hand, has dwelt upon the origin and interpretation of the coiling mechanism as typified by the large chromosomes of the genus Trillium. Both of these reviews are concerned largely with the descriptive phases of the subject. It must be realized, however, as Nebel points out, that, though the more obvious structures have been resolved, further progress is likely to be slow and difficult because of the illusory images obtained of the finer details through refraction and interference. Other avenues of approach must be found to attack the problems in this field.

That our understanding of the coiling mechanism can be pushed somewhat further through the use of abnormal material and various environmental agents has been demonstrated. Huskins and Wilson (1938) and Wilson and Huskins (1939) did this in Trillium, using heat-treated, asynaptic, and desynaptic material, whereas Swanson (1942 a, b), using Tradescantia, employed heat and ultraviolet treatments. The picture obtained in Tradescantia differs considerably from that presented by Wilson and Huskins (1938) in Trillium, but agrees with unpublished observations which the writer has made in other plant and animal materials. It is the purpose of this paper to enlarge upon earlier observations (Swanson, 1942a), and to present new material pertinent to the subject of chromosome coiling. The technical details of the experiment have been previously described (Swanson 1942a).

MEIOTIC COILING IN TRADESCANTIA

It has been a common observation in a variety of organisms, Trillium excepted (Wilson and Huskins, 1939; Huskins, 1941), that the overall chromosome length is progressively reduced between pachytene and metaphase. In Osmunda (Manton, 1939) this shortening is considerable, the metaphase chromosomes being only one eighteenth of their pachytene length. In Tradescantia the reduction, not quite so extreme, is nearer to one tenth for meiotic, and to one third to one fifth for mitotic, chromosomes (Sax and Sax, 1935). The theory generally held is that the contraction is due to the formation of a coiled condition by the previously uncoiled pachytene thread; this is implied by the appearance of a regularly spiraled metaphase chromosome.

With the exception of Trillium (Huskins, 1941, for review) there is but little literature dealing with the time interval of coiling between pachytene and metaphase. Darlington (1939) makes the general statement that large coils arise from smaller ones — a statement to which the writer wholly subscribes — but there are no experimental data bearing on this subject outside of Koller's (1938) observations on mitotic coiling in the golden hamster and a preliminary report on Tradescantia (Swanson, 1942a). Several questions might be raised at this point. How does the major coil arise? What is the origin of the minor coil and what is its temporal relationship to the major coil? What is the behavior of these two kinds of coils once they have been formed? What rôle does the matrix play in chromosome coiling? An attempt will be made to answer these questions, at least in part.

In Tradescantia it is possible to approach these problems through the application of heat, more especially, heat shocks at 40° C. At normal temperatures seven to eight coils per chromosome are characteristic (Pl. I A); high temperatures strikingly alter the coiling behavior. Either the coils are more numerous (Pl. I B) or less numerous (Pl. I C) or they exhibit an unstable condition, stretching out under anaphase tension (Pl. I D). The latter condition has been interpreted as resulting from lessened viscosity of the matrix, whereas the other two are derived from a condition in which the chromosomes and spindle are out of step with each other. Their usual coördinated behavior is disrupted by a speeding up or a slowing down of the

coiling or spindle development (Fig. 1), leading to elongated or greatly contracted chromosomes. Piecing together the varied heat-induced phenomena into an integrated whole permits one to visualize the coiling mechanism as it operates in both time and space. Meiotic coiling in Tradescantia appears to take the following course.

In early diplotene the relatively straight and, to all visible appearances, uncoiled homologous chromonemata develop a series of fairly regularly spaced minute spirals which are destined to become the major coils of metaphase. Each chromatid behaves as a separate unit (Pl. IE), and, contrary to Darlington (1937), is not coiled relationally around its sister chromatid, at least from the centromere to the nearest chiasma. This condition permits of paranemic separation of chromatids at anaphase. The freedom of chromatids implies that during the elongation that occurs between leptotene and pachytene (Belling, 1928; Manton, 1939) the relational coil resulting from the somatic coils of the premeiotic anaphase (Sparrow, Huskins, and Wilson, 1941) must have been eliminated by the straightening-out and rotation of the chromosome ends. Manton (1939) considers relational coiling to be present at pachytene in Osmunda, but no evidence bearing on this question has been seen in the present material. Wilson and Huskins (1939) state that, since the chromatids are closely associated during spiralization, they should coil in unison and similarly. Though this is generally the rule in Tradescantia, several instances have been noted of a difference in direction of coiling in sister chromatids, a condition that emphasizes in a striking manner their independence in coiling.

The sister half-chromatids also appear to be paranemically coiled (Pl. IF). The chromonemata have been so despiralized and relaxed by the heat as to permit a lateral separation of the split halves of chromatids. Matsuura and Haga (1940) have likewise shown that heat treatments can bring about a separation of sister half-chromatids (their ultramitotic type), but in view of the fact that each of these experiments has employed the use of heat, it would be premature to state that these observations invalidate the demonstration of plectonemically coiled sister half-chromatids in Trillium (Sparrow, Huskins, and Wilson, 1941), particularly since the Tradescantia microspore chromosomes show a similar relational coil under normal conditions.

The mechanism responsible for major coil initiation is unknown.

No preliminary waviness preceding a regularly formed spiral, such as has been demonstrated by Huskins (1941) in Trillium, has been found in Tradescantia. It may be, however, that this is because the present observations have not included the earliest stages, for in the camel cricket, which has a modified Tradescantia type of coiling (Swanson, unpubl.), a general waviness precedes the assumption of a regular coil (Pl. I; compare G and H).

The initiation of the major coils at diplotene constitutes the *spiralization* phase of the coiling cycle as distinguished from the later, or *despiralization*, phase (Swanson, 1942a). It is not known whether spiralization is accomplished with or without the rotation of chromosome ends. The lateral separation of chromatids at anaphase prompted Sax and Humphrey (1934) to suggest that no such rotation occurred, but since the chromatids behave separately this assumption is no longer necessary. The rôle of the matrix is problematical. If, as many workers have suggested, it determines the coiling behavior, it would appear that each chromatid must have its own matrix to coil autonomously. Kuwada (1939) considers coiling to be paralleled by a progressive dehydration of the chromosome, but whether the dehydration takes place in the chromonema or the matrix or in both is as yet undetermined.

The spiralization phase is of short duration, and is followed immediately by the despiralization phase. There is probably no time lag between the two phases because the latter is, paradoxically, but a continuation of the former, as can easily be demonstrated with a flexible wire model. It is characterized by a decrease in the number of coils, an increase in their diameter, and a marked shortening in overall chromosome length. These features are quantitatively demonstrable by a comparison of various prophase stages. It is at this stage of the coiling cycle that heat shocks (at 40° C.) are particularly effective, causing, as they do, an interruption of the coiling at different degrees of despiralization by altering the time of metaphase initiation. This temperature level probably represents, in Tradescantia, the upper limit of the chromosome-spindle coördination, and it seems very likely that its breakdown results from changes induced in the spindle-determining mechanism. A precocious spindle development brings a much-elongated chromosome to the metaphase plate (Pl. I B), whereas greatly contracted chromosomes result from a delayed spindle formation (Pl. I C). Figure 1 illustrates this graphically.

That despiralization continues well into anaphase can be shown by comparing the number of coils per chromosome at metaphase and anaphase in cells from the same anther. Anaphase counts are always smaller (Swanson, 1942a). The coil number is reduced from about

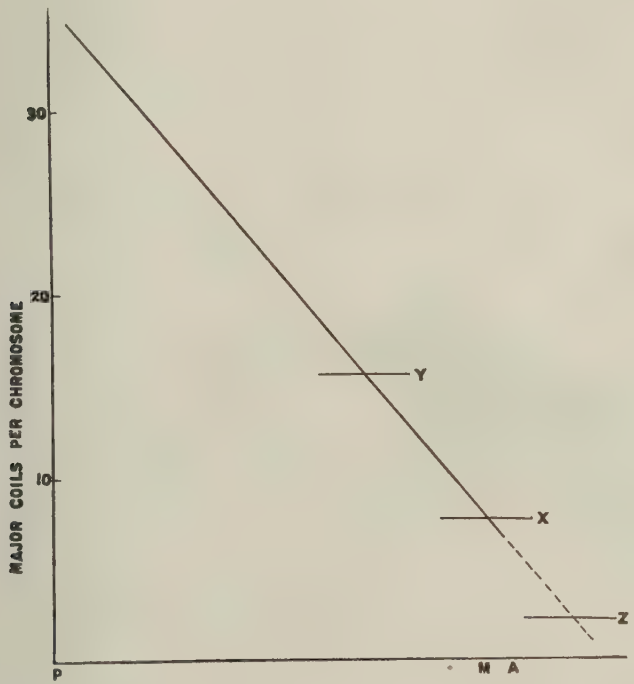


FIG. 1. The relationship of chromosome coiling to stage of division. P = prophase, M = metaphase, A = anaphase. Cross-bars (X, Y, and Z) indicate the time of appearance of metaphase in respect to coiling. X = normal metaphase, Y = precocious metaphase leading to elongated chromosomes, Z = delayed metaphase leading to greatly contracted chromosomes. The dotted part of the curve indicates the abnormal reduction in coil number resulting from a delayed metaphase

thirty-five per chromosome, the estimated number at early diplotene (Pl. 1E), to seven or eight under normal conditions, or to even fewer when the spindle is delayed. Manton (1939) states that uncoiling, or despiralization, is a feature of prophase only, whether mitotic or

meiotic, and that it never occurs at telophase. In Tradescantia this is only partially correct, for though the greater portion of despiralization is accomplished at prophase, despiralization continues until temporarily arrested at interphase, and is then resumed again at the succeeding prophase. Telophase and interphase relaxation of the coils cannot, therefore, be correctly spoken of as a process of despiralization, since the hydration of the nucleus merely loosens the coils, transforming the tight formation into the laxer relational coil of the following prophase (Sparrow, Huskins, and Wilson, 1941). Since spiralization and despiralization are but different aspects of the same phenomenon, coiling must be viewed, therefore, as a constantly recurring cycle, overlapping somewhat in prophase, interrupted for variable intervals by interphase, and finally to be arrested permanently in nondividing cells. Only during the period of meiotic pairing is there a lag between the completion of one coiling cycle and the initiation of another.

The proved reality of the minor coil (Pl. IC) suggests that most, if not all, of the contraction of chromosomes in Tradescantia is due to the coiling mechanism. As indicated by changes in coil number and diameter, the prophase development of the minor coil follows much the same course as does that of the major, i.e. progressive, despiralization. The evidence, however, is open to question because the small size makes them difficult of observation. Likewise debatable are the time and the manner of minor coil initiation (the spiralization phase). The visible appearance follows that of the major coils in Tradescantia (cf. Coleman and Hillary, 1941), but if the pachytene threads are submicroscopically coiled — not too remote a possibility in view of the observations of Manton (1939) — it is possible that their origin is at some prepachytene stage. On the other hand, they may arise *de novo* in diplotene or early diakinesis. This coil becomes the second division coil, since it is not eliminated during interphase (Nebel, 1939).

MEIOTIC COILING IN TRILLIUM

A comparison of the Tradescantia coiling cycle with that of Trillium reveals a number of differences. Our knowledge of the details of Trillium coiling has resulted from the careful and extensive work of Huskins and his coworkers at McGill University.

The most obvious difference seen in this genus is the comparative

lack of chromosome shortening during meiotic prophase (Wilson and Huskins, 1939; Huskins, 1941). The initiation of the major coil is not, therefore, a causal agent in chromosome contraction, as in Tradescantia, but is itself the result of an elongation of the chromonema, an elongation which may be the expression of an actual longitudinal growth of the chromonema (Huskins, 1941) or a reduction in gyre diameter of the minor coil (Coleman and Hillary, 1941). Wilson and Huskins (1939) look upon the coil as developing when the chromonema lengthens within a bounding pellicle; Coleman and Hillary (1941), observing that the major coils are first initiated distally, consider that they arise independently of the matrix and as a result of changes inherent in the chromonema.

A second difference lies in the fact that it is impossible to separate the Trillium prophase coiling cycle into spiralization and despiralization phases, since only the former seems to exist. Once the coils are fully established there is no change in either number or diameter until the first microspore prophase, in which they are passively straightened out and lost by the development of the somatic coil (Sparrow, Huskins, and Wilson, 1941). No active despiralization occurs. It is evident, therefore, that a marked timing difference exists between these two genera. Whereas in Tradescantia the spiralization phase is completed rapidly in early diplotene and is then followed by the despiralization phase which occupies the remainder of prophase, this entire period in Trillium is taken up by the somewhat leisurely spiralization phase, which allows the coils to assume their mature proportions directly.

The question of the presence of a minor coil in Trillium seems to have been answered photographically in the affirmative by Coleman and Hillary (1941), although Huskins (1941), in his recent review, still maintains that he can detect but a slight "waviness" along the length of the chromonema. Like the major coil, it is paranemic in nature.

Trillium possesses no interphase, but retains its coiled condition into the second division telophase.

THE MATRIX

It is evident that the behavior of the matrix in Tradescantia and Trillium must be quite different. The matrix of the former has to contract in length and increase in diameter as prophase progresses;

in the latter it must behave in a more or less static fashion, with the coils developing within its unchanging boundaries. However, the dynamics of matrical behavior are as yet only poorly understood, although the recent interest in this portion of the chromosome structure (see discussion following Huskins paper, 1941) indicates a growing realization of its importance in chromosome behavior.

Sax and Humphrey (1934), Wilson and Huskins (1939), and Kuwada (1939), in their coiling hypotheses, consider the matrix to be one of the determining factors in coiling. It limits, by means of its outside boundary, the length and width of the chromosome. When it is absent, owing to heat treatment, major coiling does not occur (Huskins, 1941). Similar uncoiled chromosomes have been observed in Tradescantia, after heat shocks, but the matrical situation was undetermined. Swanson (1942b) has recently demonstrated, in the generative nucleus, that short wave-length radiation in the ultraviolet region (2537 Å) materially affects the matrix, bringing it clearly into view as a transparent hyaline structure, and at the same time visibly shortening the chromosomes. Long wave-length radiation (2967 Å and 3022 Å) had no effect on either matrix or chromosome length. It would appear that there exists a distinct correlation between matrical development and chromosome contraction, though the issue is clouded by the fact that a small percentage of cells appear in which the chromosomes are greatly contracted but in which the matrix is not visible.

In passing, it is of interest to consider the development and synthesis of the matrix. It has been generally considered that the matrix becomes more and more of a distinct entity as the division cycle approaches metaphase. This growth appears to be strikingly correlated, in a negative fashion, with the growth relationships of nucleolus, i.e. as the nucleolus decreases in size the matrix increases, and vice versa. Gates (1938) has previously suggested that a close relationship exists. Other lines of evidence support Gates' suggestion. Staining reactions show that these two structures are similarly affected by certain stains; Schultz (1941) has demonstrated chemically that the protein of the matrix of the salivary gland chromosomes is closely related to that in the nucleolus, and that ribose nucleic acids may be similarly shared; and, lastly, McClintock (1934) has proved that, when the organizer is absent, nucleolar material is released from each chromosome in the form of droplets. It is

apparent that this seemingly intimate relationship between the nucleolus and the matrix is in need of further study.

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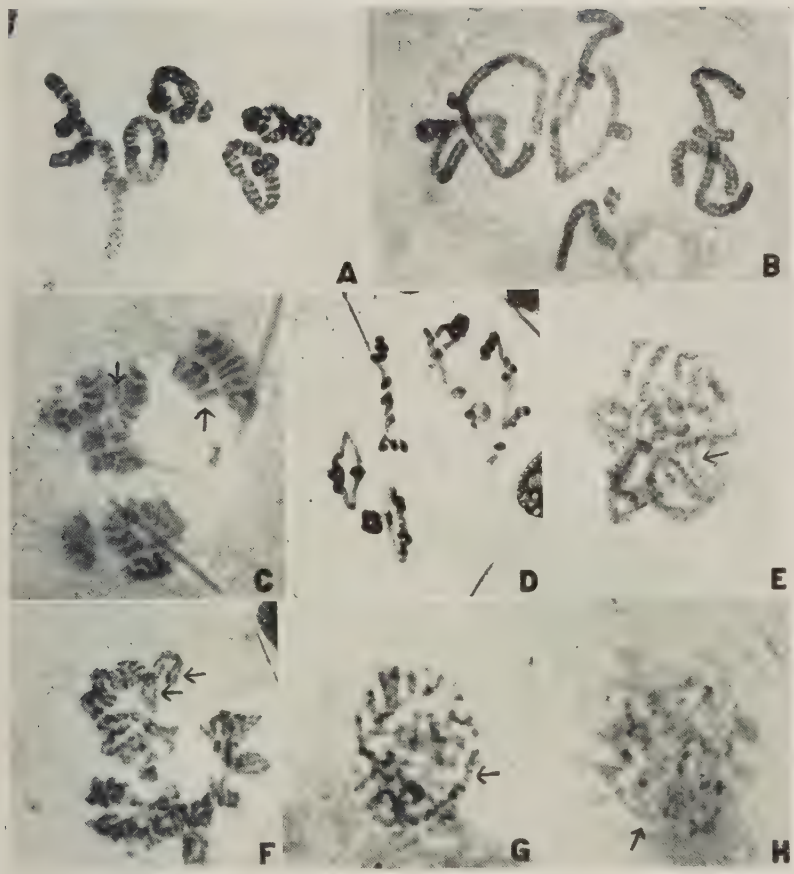

PHOTOMICROGRAPH OF MEIOTIC CELLS IN VARIOUS STAGES OF COILING

A–F. *Tradescantia canaliculata* Raf.

A. Metaphase under normal conditions
B. Elongated chromosomes at metaphase due to a precocious spindle. 40° C.
C. Shortened chromosomes due probably to a delayed spindle; arrows point to the minor coils. 40° C.
D. Major coils stretching under anaphase tension (arrow). 40° C.
E. Diplotene. Arrow indicates separate chromatids; coils appear as chromomere-like dots. 40° C.
F. Shortened chromosomes. Half-chromatids separating laterally. 40° C.

G–H. Camel cricket

G. Irregular coil (arrow) formed at time of major coil initiation
H. Regular coil, which develops at a later stage

MARINE ALGAE FROM HAITI COLLECTED BY H. H. BARTLETT IN 1941

WM. RANDOLPH TAYLOR

THE island of Hispaniola, second largest of the Greater Antilles, was long the least known of the group, so far as its algal flora is concerned. There are a few old records from the eastern Dominican Republic and a short but good account, by Børgesen, of algae from the adjacent Beata Island. On three previous occasions (Taylor and Arndt, 1929, p. 561; Taylor, 1933, p. 395; Taylor, 1940, p. 549) the writer has had opportunity to list algae from the western part of the island, in the Republic of Haiti. Including those in the account here offered, the number of algae known from Hispaniola exceeds two hundred, but this is probably less than half the total which thorough study would show. Nevertheless, we now have a tolerable idea of the flora of the western part of the island.

The present collection of material was made in 1941 by Professor H. H. Bartlett, of the University of Michigan, to whom the writer is greatly indebted for the opportunity of studying it and for the descriptions of the localities involved.

The first collection (May 1) was made south of Dame Marie toward Anse d'Hainault, at the western end of the southern peninsula. Here there is a sandy beach sloping to about 4 feet below low tide, and having an irregular bottom of sand and eroded limestone, which is exposed to a heavy surf, so that there is generally a good deal of sand suspended in the water. At the southern end hard limestone cliffs terminate the beach, descending to deep water in an exposed position. The algal flora was rather rich, with rock-attaching reef forms and a number of forms suited to tide pools having some slight protection.

The second collection (May 6) came from La Pointe, at Jérémie, on the north coast of the southern peninsula. Here wave-worn and eroded reefs of limestone and conglomerate were exposed to heavy seas. Pools in holes were filled with Turbinaria, but in general the

specimens came from shallow but very rough water. The flora was a varied one.

Trou Cochon, also near Jérémie, is a cove open to heavy seas, with a steep sand beach at the center flanked by vertical sea cliffs of hard limestone. The collections (May 9) were made from the cliffs and from large detached masses of limestone, or from floating material, and showed a good variety.

Between Jérémie and Les Roseaux, collections (May 10) were made over a limestone bottom which was partly sand-covered, being occupied by eelgrasses at a depth of 3–5 feet, with occasional deeper pools bare of grass. This was a protected station, guarded by offshore reefs in ordinary weather. The flora was not very varied, and was marked by Halimedas, Galaxauras, Codium, and similar forms which prefer quiet water.

Léogane is another station on the north shore, 32 km. west of Port-au-Prince, and the habitat was a sheltered cove behind reef and mangrove, where the sandy bottom in shallow water was overgrown by eelgrasses. The flora collected (June 1) was not a rich one, being marked chiefly by Acanthophora and Hypnea, with some Dictyota and Chaetomorpha.

On the south shore of the peninsula collections (May 13) were made at Saint Louis du Sud, where the bottom was flat and sandy to muddy, with a good deal of eelgrass in the notably warm water. The collections yielded little variety, but contained a good deal of Gracilaria, Hypnea, and Enteromorpha, as is appropriate to the type of location.

The final collection (June 23) was made on an island lying off Anse à Margot (Bayeux), on the north coast between Cap Haitien and Le Borgne. Here a narrow reef of coral, mostly dead and worn or covered with sand, stood between the sea and deeper pools full of Turbinaria; at low tide, when the reef was not covered, the water in these became quite hot. A large variety of algae were represented, but chiefly species suited to quiet water.

Discovery in one of the Bartlett collections of a gelidiaceous plant quite different from anything familiar to the writer impelled him to reconsider all of his specimens from the warmer seas of America and to borrow pertinent material from the New York Botanical Garden, for the loan of which he is greatly indebted. The result of a study of this material was the conviction that few of the American tropical

or subtropical plants can be considered identical with those from temperate waters, and that the bulk of the specimens hitherto collected had been misidentified. Without confidence that further changes may not be necessary, the writer offers in the course of this paper certain new species and new identifications as promising some clarification of the confusion of forms long known to exist in this family in the American area.

List of Species

MYXOPHYCEAE

OSCILLATORIACEAE

Lyngbya confervoides C. Agardh. — Bayeux, *17987* (det. F. Drouet).

Phormidium Crosbyanum Tilden. — Bayeux, *17996* (det. F. Drouet).

RIVULARIACEAE

Calothrix crustacea Thuret. — Les Roseaux, *17841* (det. F. Drouet).

CHLOROPHYCEAE

ULVACEAE

Enteromorpha flexuosa (Wulfen) C. Agardh. — Saint Louis du Sud, *17956*.

Enteromorpha lingulata J. Agardh. — Dame Marie, *17833;* Jérémie, *17888*.

Ulva fasciata Delile. — Jérémie, *17885*.

VALONIACEAE

Anadyomene stellata (Wulfen) J. Agardh. — Jérémie, *17875*.

Cladophoropsis membranacea (C. Agardh) Borgesen. — Dame Marie, *17844;* Jérémie, *17890;* Léogane, *17961;* Bayeux, *17985*.

Dictyosphaeria cavernosa (Forsskål) Borgesen. — Dame Marie, *17838*.

Valonia macrophysa Kützing. — Dame Marie, *17834*.

Valonia ocellata Howe. — Dame Marie, *17840;* Jérémie, *17886;* Bayeux, *17982*.

CLADOPHORACEAE

Chaetomorpha brachygona Harvey. — Saint Louis du Sud, *17959*.

Chaetomorpha clavata (C. Agardh) Kützing. — Trou Cochon, *17929*.

Chaetomorpha geniculata Montagne. — Léogane, *17962*.

Chaetomorpha media (C. Agardh) Kützing. — Dame Marie, *17848;* Jérémie, *17887;* Trou Cochon, *17912*.

Cladophora fascicularis (Mertens) Kützing. — Dame Marie, *17821*.

Cladophora fuliginosa Kützing. — Jérémie, *17891*.

Cladophora Howei Collins. — Jérémie, *17898*.

DASYCLADACEAE

Cymopolia barbata Lamouroux. — Bayeux, *17986*.

BRYOPSIDACEAE

Bryopsis pennata Lamouroux. — Jérémie, *17873*.

CAULERPACEAE

Caulerpa cupressoides (West) C. Agardh. — Bayeux, *17976*.

Caulerpa cupressoides var. mamillosa (Montagne) Weber-van Bosse. — Les Roseaux, *17847*.

Caulerpa racemosa (Forsskål) J. Agardh. — Bayeux, *17972*.

Caulerpa sertularioides f. brevipes (J. Agardh) Svedelius. — Les Roseaux, *17846;* Bayeux, *17872*.

CODIACEAE

Avrainvillea levis Howe. — Trou Cochon, *17829*.

Avrainvillea Rawsonii (Dickie) Howe. — Dame Marie, *17828;* Bayeux, *17993*.

Codium dichotomum (Hudson) Setchell. — Jérémie, *17874;* Les Roseaux, *17948;* Bayeux, *18000*.

Halimeda Monile (Ellis and Solander) Lamouroux. — Dame Marie, *17854;* Léogane, *17969*.

Halimeda Opuntia (Linnaeus) Lamouroux. — Dame Marie, *17824;* Bayeux, *17983*.

Halimeda tridens (Ellis and Solander) Lamouroux. — Les Roseaux, *17935*.

Halimeda tridens var. tripartita (Barton) Collins. — Dame Marie, *17853*.

Penicillus capitatus Lamarck. — Dame Marie, *17845;* Bayeux, *17979*.

Penicillus pyriformis Gepp. — Dame Marie, *17855*.

Udotea Flabellum (Ellis and Solander) Howe. — Dame Marie, *17837*.

PHAEOPHYCEAE

RALFSIACEAE

Ralfsia expansa J. Agardh. — Dame Marie, *17863*.

DICTYOTACEAE

Dictyopteris delicatula Lamouroux. Jérémie, *17889;* Les Roseaux, *17941*.

Dictyopteris plagiogramma (Montagne) Vickers. — Trou Cochon, *17917*.

Dictyota cervicornis Kützing. — Dame Marie, *17859;* Bayeux, *17975*.

Dictyota ciliolata Kützing. — Les Roseaux, *17950*.

Dictyota dentata Lamouroux. — Trou Cochon, *17922*.

Dictyota divaricata Lamouroux. — Dame Marie, *17825;* Léogane, *17965*.

Padina gymnospora (Kützing) Vickers. — Dame Marie, *17860c;* Jérémie, *17902b;* Bayeux, *17978* (all det. F. Thivy).

Padina sanctae-crucis Borgesen. Dame Marie, *17860a;* Jérémie, *17902a;* Léogane, *17966;* Bayeux, *17977* (all det. F. Thivy).

Padina Vickersiae Hoyt. - Dame Marie, *17860b;* Les Roseaux, *17947* (both det. F. Thivy).

Zonaria variegata (Lamouroux) C. Agardh. Trou Cochon, *17918*.

Zonaria zonalis (Lamouroux) Howe. — Dame Marie, *17843*.

FUCACEAE

Sargassum Filipendula C. Agardh. — Trou Cochon, *17908*.

Sargassum fluitans Borgesen. — Trou Cochon, *17906*.

Sargassum lendigerum (Linnaeus) Kützing. — Trou Cochon, *17924.*

Sargassum natans (Linnaeus) J. Meyen. — Jérémie, *17878;* Trou Cochon, *17905.*

Sargassum platycarpum Montagne. — Dame Marie, *17856;* Jérémie, *17876;* Trou Cochon, *17907;* Bayeux, *18003.*

Sargassum polyceratium Montagne. — Dame Marie, *17857;* Jérémie, *17880;* Trou Cochon, *17909;* Bayeux, *18004.*

Sargassum vulgare C. Agardh. - Dame Marie, *17858;* Jérémie, *17879;* Trou Cochon, *17910.*

Turbinaria turbinata (Linnaeus) Kuntze. Jérémie, *17881;* Trou Cochon, *17911;* Bayeux, *17970.*

RHODOPHYCEAE

HELMINTHOCLADIACEAE

Liagora ceranoides Lamouroux. — Bayeux, *17973.*

Liagora valida (Forsskål) C. Agardh. — Trou Cochon, *17930.*

CHAETANGIACEAE

Galaxaura cylindrica (Solander) Kjellman. - Les Roseaux, *17946.*

Galaxaura flagelliformis Kjellman. — Bayeux, *18001.*

Galaxaura marginata (Ellis and Solander) Kjellman. - Jérémie, *17883;* Les Roseaux, *17945.*

Galaxaura oblongata (Ellis and Solander) Lamouroux. — Trou Cochon, *17923.*

Galaxaura obtusata (Ellis and Solander) Lamouroux. — Trou Cochon, *17933.*

Galaxaura rugosa (Ellis and Solander) Lamouroux. — Jérémie, *17884;* Les Roseaux, *17946b;* Léogane, *17968;* Bayeux, *17997.*

Galaxaura squalida Kjellman. - Jérémie, *17867;* Trou Cochon, *17934;* Les Roseaux, *17939;* Léogane, *17967;* Bayeux, *17900.*

Galaxaura subverticillata Kjellman. — Bayeux, *17998.*

Gloiophlaea caribaea, sp. nov.[1] (Pl. I, Fig. 2). — Plant arising from a short conical base, 3–4 cm. tall, bushy, reddish brown near the

[1] **Gloiophlaea caribaea,** sp. nov. — Planta monoica, 3–4 cm. alta, fruticiformis; caule primario brevi, dichotome repetiter (10–13) ramoso, ramulis deorsum 0.5–0.7 mm. crassis sursum prope apicem 1.25 mm. crassis; axi ex filamentis multis crassiusculis inter alia tenuiora formantia corticem interiorem

tips of the branches, much darker below; the primary stem short, the branching above dichotomous, with members of some forkings surpassed in development by those of others, the divisions to 10–13 stages at least; when dried the branches 0.25 mm. diam. near the base of the plant and 0.80 mm. near the tips, when soaked, up to 0.50–0.70 mm. diam. below and up to 1.25 mm. near the tips; axis consisting of many stouter filaments 6–14 μ diam., with relatively thick walls, loosely disposed in an area 250 μ diam. and having among them many more slender filaments, about 2 μ diam., which continue out to form the loose inner cortex; outer cortex about 33 μ thick, with one layer of ovate-turbinate colorless utricles supported by an inner layer of large oval cells, which, in converging series, are connected in a few stages with the slender filaments by small rounded cells; slender colored filaments penetrating between the utricles; monoecious, the spermatangia widespread, formed in the younger parts of the plant on the ends of the superficial filaments between the utricles; cystocarps abundant, first appearing only one or two forkings below the branch tips, mature in the middle portion of the plant, subspherical or depressed, 160 175 μ diam., with 5–8 layers of coherent filamentous pericarp.

Type. — Trou Cochon, west of Jérémie, *H. H. Bartlett 17920*, May 9, 1941, in Herb. Univ. Mich.

These specimens come close to *Gloiophlaea Halliae* Setchell (1914, p. 116) in microscopic characters, differing chiefly in the prominence of the axial strands and in the size of the cystocarps. Macroscopically the differences are more marked. The plants in the present collection, in spite of being only about a third as tall as Setchell's species, branch twice as often, so that the segments average much shorter, the distance between the forks being in general only 2–3 mm. and in but one case reaching 5 mm. The diameter of the segments, too, seems only about half of that in his plants. It is not inconceivable that the variations are within

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constante; cortice exteriore ca. 33 μ crasso, extus constante ex utriculis pellucidis ovato-turbinatis, intus ex cellulis magnis ovalibus somata chromatophora includentibus; spermatangiis ubique dispersis in ramulis junioribus; cystocarpiis abundanter in parte plantae media maturantibus, diametro ca. 160–175 μ, vestitis cum laminis 5–8 filamentosis pericarpialibus cohaerentibus. Habitat in loco dicto Trou Cochon prope Jérémie, Haiti, legit H. H. Bartlett, n. 17920, 9 Mai., 1941; specimen typicum in Herb. Univ. Mich. conservatum.

the range of one species, but, with only two collections known, that can hardly be established.

GELIDIACEAE

Gelidiella acerosa (Forsskål) Feldmann and Hamel. — Jérémie, *17822;* Dame Marie, *17850;* Les Roseaux, *17942;* Saint Louis du Sud, *17952;* Bayeux, *17999.*

Gelidiella trinitatensis, sp. nov.[2] (Pl. I, Fig. 1). — Plant minute, the basal filaments entangled, cylindrical, about 55–75 μ diam., with erect cylindrical or compressed filaments up to 2, rarely 5, mm. tall, 75–90 μ diam., simple or irregularly and sparingly branched, terminally or laterally bearing cylindrical to generally flat simple or pinnate to subpalmate tetrasporangial branchlets; tetrasporangia originating in clear V-shaped rows, later obscured, near the apices, the spores being shed first from the lower portions of the branchlets.

Type. — Manzanilla Point, Trinidad, British West Indies, *R. Thaxter,* April 14, 1913 (Taylor, 1929, p. 623, as *Gelidium crinale*), in Herb. W. R. Taylor.

In this family the first new entity, *Gelidiella trinitatensis,* is a minute creeping plant which probably came from rocks in shallow water along shore, since fragments of Bryocladia are mixed with it. Until the arrangement of the sporangia is noted this plant might be mistaken for a form of *Gelidium pusillum* lacking flat blades, or for a miniature *Gelidium crinale.* It seems amply distinct from either of these and nearest *Gelidiella tenuissima* Feldmann and Hamel (1936, p. 226), for the stem structure is similar in section and most of the superficial characters are likewise in agreement. The fertile branchlets in that species are not forked, however, as here, nor are the erect branches compressed.

[2] **Gelidiella trinitatensis,** sp. nov. — Planta minuta, filamentis basalibus cylindricis, repentibus, intertextis, ca. 55–75 μ crassis; filamentis erectis cylindricis vel compressis, plerumque 2 mm., raro 5 mm., altis, 75–90 μ crassis, simplicibus vel irregulariter sparse ramosis, ad apicem vel secus ad latera tetrasporangiales ramulos saepe cylindricos vel plerumque compressos, simplices vel pinnatos vel subpalmatos ferentibus; tetrasporangiis in seriebus regulariter V-formibus prope apices formantibus, deinde irregulariter dispositis; sporis in parte ramulorum inferiore primum maturantibus. Habitat in loco dicto Manzanilla Point, I. Trinidad, British West Indies, legit R. Thaxter, 14 Apr., 1913; specimen typicum in Herb. W. R. Taylor conservatum.

When the plants of *Gelidiella trinitatensis* under study showed very small tetrasporangial sori on cylindrical branches, the branches appeared stichidium-like. Where the branchlets were simple but more productive they became band-shaped and about 85–90 μ wide by 400–500 μ long, with the V-shaped rows of sporangia and, at the oldest stages, very evident sporangial cavities. The forked branchlets were sometimes flat, sometimes, if narrow, only compressed. One fragment associated with this material but not seen to be attached to the same horizontal filaments may represent a further development. It consisted of a flat linear-oblanceolate blade 8 mm. long, 375 μ diam., with nine similar linear-lanceolate branchlets pinnately crowded near the tip, and two isolated smaller ones below. These were fertile near the tips, the linear sporangial portion reaching 1.25 mm. in length.

GELIDIUM CORNEUM (Hudson) Lamouroux

This plant has been reported from many places in the Americas, but not, so far as the writer is aware, from Haiti. He was inclined to identify one of the specimens of the present series as *Gelidium corneum*, in conformity with other specimens so identified by him in the past, and in making an examination of transverse sections found among his materials some with the stem structure and cystocarp structure of Gelidium; others, however, resembled Pterocladia. The structure of the stem was often confusing, but the net result was that he could confirm from materials available to him only a very few records of *G. corneum* and found it necessary to move most of the specimens to Pterocladia. Records which seem without doubt correctly assigned to Gelidium, and which are probably correctly placed under *G. corneum*, are noted below.

Distribution. — PANAMA: Careening Cay, *Dodge 75*, Sept. 7, 1925 (cystocarpic). MARTINIQUE: *G. Hamel and A. Hamel-Joukov 84*, March, 1930 (tetrasporic).

These specimens are clearly pinnately branched, with regular gradations of branches from the tips. The cystocarpic specimens tended to be more consistently twice-pinnate than the tetrasporic ones. The structure was obviously cartilaginous, and the branches were quite thick for their breadth. In section the slender refractive filaments called "rhizines" were more or less restricted to the outer tissues.

Gelidium crinale (Turner) Lamouroux var. **platycladum,** var. nov.[3] (Pl. II, Fig. 1). — Plants to 7–10 cm. tall, dark reddish purple, the base with a few flagelliform branches, mostly erect, the main axes often being twisted together, flat except at the extreme base, to 550 μ wide and 125 μ thick, but somewhat broader at the forkings; in section rhizines few, inconspicuous, and in the outer part of the central tissue; branching irregularly dichotomous below, seemingly alternate above, the ultimate divisions subcorymbosely crowded, acute-tipped; cystocarps not conspicuous, bilocular, in the ultimate or penultimate branchlets, causing a swelling on both faces; tetrasporangia in the acute, very slightly expanded branchlets of the last two or three divisions, irregularly placed, discharging from the apices first and only later in the lower parts of the sori, the tips sometimes decaying.

Type. — Port Aransas, Texas, *C. J. Reed 47*, May 20, 1932, in Herb. W. R. Taylor.

Distribution. — Texas: Galveston, *Smith*, June, 1937; Goose Island, *Smith*, Oct., 1937; Rockport, *Reed*, Jan., 1936; Port Aransas, *Sanders 4, 6*, April, 1931, in Herb. N. Y. Bot. Gard., Herb. W. R. Taylor; Corpus Christi, *Reed*, Feb., 1939; Boca Chica, *Clover*, Aug. 8, 1932, in Herb. Univ. Mich. Florida: St. Augustine, *Reynolds*, no date, in Herb. N. Y. Bot. Gard.; Hillsborough Bay, *McFarlin*, May, 1931, in Herb. Univ. Mich.; Pensacola, *Belknap*, no date, in Herb. N. Y. Bot. Gard.

These plants differ strikingly from *Gelidium crinale* of northern waters. They are much more robust, and the axes are for the most part flattened except at the base, whereas in typical *G. crinale*, which is ordinarily cylindrical, they may occasionally show a little compression. The branchlets are more markedly clustered, sometimes in quite congested groups, and in the tetrasporangial plants are much more sharp-tipped. Flattening of the tetrasporangial branches is not conspicuous, the fertile portion being

[3] *Gelidium crinale* (Turner) Lamouroux var. **platycladum,** var. nov. — Plantae plerumque 7–10 cm. altae, ramis erectis principalibus planis, basi ultima excepta, sursum alterne ramosis; ramulis ultimis subcorymbose aggregatis, apice longe acutissimeque apiculatis; tetrasporangiis positis in divisionibus 2 vel 3 ultimis et paene ultimis; ramulis eis subultimis tetrasporiferis vix expansis sed compressis, pinnatis vel palmatis; apicibus acutis. Habitat in loco dicto Port Aransas, Texas, U. S. A., legit. C. J. Reed, n. 47, 20 Mai., 1932; specimen typicum in Herb. W. R. Taylor conservatum.

merely a continuation in shape of the vegetative axis, and so differing from the northern form, where the expansion of the sporangium-bearing part is evident. Some tropical and subtropical specimens, however, agree with those from the north, and the differences are interpreted as varietal. Børgesen (1934, p. 3; 1939, p. 106) has described under the name *G. heteroplatos* a parallel form from India.

Gelidium floridanum, sp. nov.[4] (Plate III, Figs. 1–2). — Base ramified, the entangled branches cylindrical, reflexed and somewhat flagelliform, basal branches giving rise to erect subsimple strap-shaped branches which at full development become about 1 mm. wide, 13 cm. tall, sparingly pinnately branched below, commonly regularly distichous in the upper portions of well-grown plants; sections of main branches showing numerous rhizines more or less in small groups scattered through the central and the peripheral tissue, but somewhat more abundant in the peripheral; sterile branchlets spreading, strap-shaped, contracted at the base and obtuse at the apices; fertile branchlets in crowded pinnate clusters on the lower portions of the main branches; tetrasporic branchlets at first simple, obovate, becoming ligulate, then pinnately branched, with the sorus occupying the central portion of the branchlets, surrounded by a firm sterile border; cystocarpic branchlets with one, seldom two, cystocarps in each branchlet, becoming pinnate, the cystocarps bilocular, swollen and with a slightly projecting ostiole; after discharge of tetraspores or of carpospores the fertile segments often becoming perforate.

Type. — Indian River, Florida, *E. Palmer 47*, 1874 (tetrasporic), in Herb. N. Y. Bot. Gard.

Distribution. — Florida: Cape Malabar, *F. A. Curtiss*, no

[4] **Gelidium floridanum,** sp. nov. — Planta erecta matura 13 cm. alta, ramis primariis compressis, ca. 1 mm. latis, deorsum sparse pinnateque ramosis, sursum distiche ramosis, in sectione transversali filamenta rhizoidalia ("rhizina" auctorum recentiorum) ostendentibus, eadem fasciculos parvos in partibus interioribus et exterioribus formantia; ramulis sterilibus patentibus, liguliformibus, basi contractis; ramulis fertilibus in greges pinnatos aggregatis in parte ramorum principalium inferiore; ramulis tetrasporiferis ultime pinnatis, soros centrales margine sterili cinctos ferentibus; cystocarpiis bilocularibus singulis vel binis in segmento singulo ramulorum ultime pinnatorum. Habitat in loco dicto Indian River, Florida, U. S. A., legit E. Palmer, n. 47, 1874; specimen typicum in Herb. N. Y. Bot. Gard. conservatum.

date, in Herb. N. Y. Bot. Gard.; Oceanus, *A. H. Curtiss*, July, 1876 (cystocarpic), in Herb. N. Y. Bot. Gard.; Indian River, *Palmer 47*, 1874 (several specimens, cystocarpic and tetrasporic) in Herb. N. Y. Bot. Gard. TRINIDAD: Maqueripe Bay, *Thaxter*, 1912–13 (tetrasporic).

This plant strongly resembles *Gelidium clavatum* Okamura (1934, p. 61, pl. 28). It differs in the more regularly pinnate narrower fronds, and in the very notable congestion of the reproductive branchlets, a feature not described for Caribbean Gelidia.

Pterocladia americana, sp. nov.[5] (Pl. IV, Fig. 1). — Plant stoloniferous below with a subcylindrical horizontal axis, this feature being inconspicuous in luxuriant tufts; the basal portion giving rise to simple erect flat blades to 0.5–2.0 cm. tall or to blades more or less pinnately branched; in bushy plants of larger size, up to 5–6 cm., the axis sparingly pinnately branched and rebranched, becoming obscure in the tetrasporangial plant, where the branches are fastigiate, but in the sexual plants frequently more regularly pinnate, though the upper branches often seem palmate by reason of condensation of the axis; the branchlets tending to appear erect, their bases subcylindrical, somewhat contracted and at first upcurved, though later spreading, flat in the distal portion, to 500–650 μ wide and 75–150 μ thick; all axes quite flat, often submembranous, with the rhizines chiefly in the central region; tetrasporangia in all growth forms, in the simple blades occupying the distal portion, the sporangia originating in clear V-shaped rows; in the smaller crowded branching plants the sporangia appearing in practically unmodified branchlets of the last 1–2 orders, again occupying the full width of the thin blades; the cystocarps causing a slight broadening of the branchlet bearing them, a slight swelling on the ventral, and a marked one on the dorsal surface, where the ostiole is eventually somewhat raised; only one chamber and one spore group.

[5] **Pterocladia americana,** sp. nov. — Planta interdum 5–6 cm. alta, fruticosa, pinnate sparse ramosa; ramis fastigiatis, erectis, basi subcylindricis, paulum contractis curvatisque, sursum plantis non plus quam 500–650 μ latis, 75–150 μ crassis; tetrasporangiis in ramulis ordinariis ultimis vel paene ultimis positis, in seriebus primum V-formibus sed irregularibus et prope maturitatem deinde plus minusve inordinatis; ramis apice obtusis, aetate filamenta rhizoidalia plerumque axialia ostendentibus. Habitat in loco dicto Port Antonio, Jamaica, legit Pease et Butler, Phyc. Bor.-Am. n. 783, Jul., 1900 (sub nom. *Gelidium caerulescens* Crouan); specimen typicum in Herb. W. R. Taylor conservatum.

Type. — Port Antonio, Jamaica, *Pease and Butler*, Phyc. Bor.-Am. *783*, July, 1900 (sub nom. *Gelidium caerulescens* Crouan), in Herb. W. R. Taylor.

Distribution. — North Carolina: Beaufort, Fort Macon, *Hoyt*, Aug. 20, 1906, in Herb N. Y. Bot. Gard.; Duncan Breakwater, *Hoyt*, Sept. 15, 1906, in Herb. N. Y. Bot. Gard.; Shark Shoal Breakwater, *Blomquist 11436*, Oct. 19, 1940 (all three being dwarf forms). Bermuda: Tuckers Town, *Hervey*, Phyc. Bor.-Am. *2182a*, Feb. 24, 1915 (slender form). Jamaica: Port Antonio, *Pease and Butler*, July, 1891, in Herb. N. Y. Bot. Gard. Barbados: Bathsheba, *Vickers 119*, Jan. 26, 1903 (a dwarf form), in Herb. N. Y. Bot. Gard. Tobago: Buccoo Reef, *Taylor 39–558c*, April 20, 1939 (an extreme dwarf form), in Herb. Univ. Mich. Texas: Port Aransas, *Sanders 5*, March 27, 1937, in Herb. Univ. Mich. Costa Rica: Piuta Point, *Dodge 11*, March 20, 1930 (a dwarf form). Venezuela: Cubagua Island, *Taylor 39–473*, April 14, 1939 (an extreme dwarf form), in Herb. Univ. Mich.

Material of this species has passed under the name *Gelidium caerulescens* for some time. Although the name is quite often ascribed to the Crouans (in Mazé and Schramm, 1870, p. 199), they are not its authors, but rightly refer it to Kützing (1868, p. 19, pl. 56 c–d), whose type came from New Caledonia, and they do not describe the Guadeloupe plant for which they use this name in any of the editions of the Guadeloupe flora to which they contributed, but merely mention its color. Examination of material from New Caledonia in the Herbarium of the New York Botanical Garden shows that it has typical Pterocladia structure, but apparently is sterile; this material, dating from Vieillard, 1863, is marked by Howe, in pencil, "cotype," which is probably correct. One notes that Weber–van Bosse (1913–28, p. 225) refers Kützing's plant to *G. corneum*, which certainly cannot be the disposition of the Jamaican plant. Close examination of American collections shows significant differences from Kützing's figure, and altogether it appears advisable to treat the American material as distinct. Børgesen (1916, p. 114) refers the Crouan plant to *G. corneum* var. *pinnata* (Hudson) Turner, which name Feldmann and Hamel (1936, p. 254) cite as a synonym of *P. capillacea* (Gmelin) Bornet and Thuret. The American material

does not closely resemble the figure of Børgesen's Virgin Island plant, which, since he designates the position of the "hypha-like filaments" — rhizines — as central, may well be a young stage of *P. capillacea*. Collins (1901, p. 252) states that Bornet had compared the Jamaican material with that from Guadeloupe and considered it to belong to the same species. Distinctive are the erect flat branches which divide and redivide pinnately without emphasis on any dominant main axes and with a tendency for the lower branches to reach a level with the others, so that the pinnate character is obscured except in the minor branches. In some Bermuda material probably belonging here, but of exceptional growth, the branch tips are elongated and attenuate.

Apparently this is a species adapted to a variety of conditions. On exposed rocks near low-water mark it may form close tufts or even mats, with the erect branches short and comparatively simple; in this state it is often much intermixed with sand. In tide pools or other protected situations it may grow considerably larger and develop the more elaborate branch system described. The writer found numerous specimens attributed to *Gelidium pusillum* which were the simpler form of this species, and would judge that it is a common plant on rocks in this dwarf state and that it relatively rarely becomes fully developed.

Pterocladia Bartlettii, sp. nov.[6] (Pl. IV, Fig. 2). — Plant dull purplish, bushy, somewhat entangled, very slender in all parts, arising from a minute flattened holdfast, from which grow one or a few cylindrical or compressed rhizomatous branches a few millimeters in length, which bear secondary holdfasts and which at first give rise to erect linear-lanceolate simple blades, up to 1 cm. in length, that soon develop into the adult ramification; mature axes to 6–8 cm. tall, several from a common base, tapering

[6] **Pterocladia Bartlettii,** sp. nov. — Planta fruticiformis plus minusve intertexta, omnibus partibus gracillima, basi ramos breves rhizomatosos ferens; axibus maturis pluribus ex ramo rhizomatoso 6–8 cm. altis utrinque angustatis, deorsum compressis vel planatis fere 0.5 mm. latis, sursum 125–170 μ crassis ramos subsidiarios bifarie alternos principalibus similes ferentibus; ramulis inter se propinquis, divaricatis vel ascendentibus, linearibus, 2 vel 3, raro 5, mm. longis, planis, apiculatis, tetrasporangia in seriebus V-formibus ferentibus; cystocarpiis unilocularibus, singulis vel raro binis positis in ramulis ultimis planis mox a latere ostiolum vix elevatum ferente flexis. Habitat in loco dicto Saint Louis du Sud, Haiti, legit H. H. Bartlett, n. 17960, 13 Mai., 1941; specimen typicum in Herb. Univ. Mich. conservatum.

to each end, compressed below, flat above, to 0.5 mm. or a little more wide and to 125–170 μ thick, bearing alternately and bilaterally numerous subsidiary axes of one or sometimes two degrees, similar to the primary but less flat, which become erect and more or less entangled below, free above; medullary filaments involved by very abundant intercellular rhizines, which dominate the interior two thirds of the axis structure; main axis and subsidiary axes closely beset with generally divaricate, occasionally ascending, branchlets in bilateral series along the margins, these sometimes, and especially above, very regular and comblike, sometimes less regularly placed and, when elongate, irregularly deflected; branchlets linear, usually flat, minutely apiculate, when small oblanceolate, when older ligulate to spathulate, the margins entire or in broader examples obscurely and irregularly serrate, but in some specimens subcylindrical and tapering, generally to 2–3 mm. long, occasionally in isolated instances to 5 mm. long; tetrasporangia in the ultimate branchlets, near the base of the plant formed in stichidium-like enlargements of the ends of the cylindrical or compressed branchlets, where they occupy the outer, or eventually the major, portion, appearing in obvious V-shaped series which become obscured as the sporangia mature; spermatangia not seen; cystocarps unilocular, produced singly or occasionally two in the generally flat ultimate branchlets, which become strongly dorsoventrally curved, the slightly elevated ostiole being formed on the dorsal side somewhat forward of the carpospore mass.

Type. — Saint Louis du Sud, Haiti, from warm quiet shallow water along the shore, *H. H. Bartlett 17960*, May 13, 1941, in Herb. Univ. Mich.

Distribution. — Texas: Copano Bay, *Smith 232*, Aug. 17, 1937 (Taylor, 1941, p. 75, as *Gelidium crinale*). Haiti: Miragoane, *C. H. Arndt 204a*, Feb., 1929; Aquin, *C. H. Arndt 118, 130*, Jan., 1929 (Taylor, 1929, p. 658, as *G. crinale*); Torbeck, *Orcutt 9607*, 1929 (Taylor, 1933, p. 404, as *G. crinale*), in Herb. Univ. Mich.

This species is readily distinguished when full grown, because it is much more slender than any other of like stature. When ill developed, however, it may cause considerable trouble, which is also true of others in the genus.

Pterocladia capillacea (Gmelin) Bornet and Flahault (Pl. II, Fig. 2).

Distribution. — Haiti: Bayeux, *Bartlett 17984*, June 23, 1941, in Herb. Univ. Mich. Santo Domingo: San Pedro de Macoris, *Rose*, March 30, 1913, in Herb. N. Y. Bot. Gard. Trinidad: Maqueripe Bay, *Thaxter*, 1912–13. Venezuela: *Kuntze*, no date, ex Herb. P. Magnus, in Herb. N. Y. Bot. Gard. Brazil: Rio de Janeiro, *Rawitscher*, in Herb. Univ. Mich. Uruguay: Isla Gorriti, *Felippone 194*, Oct. 22, 1900, in Herb. N. Y. Bot. Gard.

This plant, under the synonym *Gelidium corneum* var. *pinnatum* (Hudson) Turner, has been reported from Brazil and the Virgin Islands. In the three herbaria used for this study by far the larger number of specimens labeled *G. corneum* and coming from the area under consideration were assignable to *Pterocladia capillacea;* only a few were selected to illustrate the range cited above. In papers by Howe and by the writer these plants have been referred to *G. corneum*, but the structure of the cystocarp, the tetrasporangial branch, and the stem axis support the present determination. The distribution of the rhizines in the stem is by no means clear-cut in many cases, and as a character must be used with caution. When young, specimens of *P. capillacea* are not always to be distinguished at a glance from *P. americana*, described above, page 154. In general, they are coarser and the primary axes are far more distinct. The lateral branching is more regular, tending to produce a flat triangular blade, sometimes broad, but more characteristically narrow. At times there are very few branchlets, even on tall axes, but the writer finds no tendency toward a mosslike dwarf state, which is notable in *P. americana*. The range appears to be more strictly southern.

Wurdemannia miniata (Draparnaud ex de Candolle) Feldmann and Hamel var. **planicaulis,** var. nov.[7] — Plants to 8 cm. tall, bushy, blackish purple when dried, somewhat flagelliform-rhizomatous at the base, the erect axes very sparingly branched,

[7] *Wurdemannia miniata* (Draparnaud ex de Candolle) Feldmann and Hamel var. **planicaulis,** var. nov. — Plantae ca. 8 cm. altae, basi flagelliformi-rhizomatosae, axibus erectis sparse et irregulariter vel interdum opposite pinnatis, utrinque cylindricis sed in media parte valde compressis, interdum 1.1 mm. latis sed plerumque 0.5 mm. latis, 185 μ crassis. Habitat in loco dicto Jérémie, Haiti, legit H. H. Bartlett, n. 17896, 6 Mai., 1941; specimen typicum in Herb. Univ. Mich. conservatum.

irregularly alternate, occasionally opposite, pinnate, cylindrical near the ends, clearly compressed in the larger portions near the center of the plant, where the width may reach 1.1 mm., though usually half as much, and the thickness 185 μ; the growing tips showing clearly the fountain type of apical growth; sections of the older stems having a surface layer with radially somewhat elongated cells, then a medulla with the cells increasingly large and free from chromatophores toward the center, where the walls are moderately thick.

Type. — Jérémie, Haiti, from rocks in shallow rough water, *H. H. Bartlett 17896*, May 6, 1941, in Herb. Univ. Mich.

Distribution. — Jamaica: Kingston, *Orcutt 6383b*, 1927–28. Haiti: Jérémie, *Bartlett 17893*, *17896*, May 6, 1941. Trinidad: Sylvia Bay, *Newcombe 789*, May 15, 1938. Brazil: Ilha Govenador near Rio de Janeiro, *Schmitt 63*, Sept. 1, 1925. The Jamaica and Brazil specimens have been reported by the writer (1931, p. 302; 1933, p. 400; both as *Wurdemannia setacea* Harvey).

This material was thought to be a Gelidium until examination of the growing tip showed that the structure was of a different type; close comparison revealed that the anatomy of the axis was the same as that of Wurdemannia. The flattened character of the branches was not in accord with the descriptions of the American material of that plant, and so reëxamination of the writer's considerable suite of specimens from Florida was made. A slight compression was recognizable in two or three, but nothing very marked. In the present material from Haiti the axis was many cells wider than thick, as the surface measurements would suggest. The walls of the central cells were not thinner than those toward the outer part of the axis, as Feldmann and Hamel (1936, p. 262) have figured them, but remained moderately thick; this is as true of the more typical Florida material as it is of the proposed new variety.

RHIZOPHYLLIDACEAE

Ochtodes secundiramea (Montagne) Howe. — Dame Marie, *17831*.

SQUAMARIACEAE

Peyssonnelia Dubyi Kützing. — Bayeux, *18010*.

MELOBESIACEAE

Fosliella farinosa (Lamouroux) Howe. — Jérémie, *17856*.
Goniolithon Boergesenii Foslie. — Bayeux, *18007*.
Goniolithon decutescens (Heydrich) Foslie. — Bayeux, *18008*.
Goniolithon solubile Foslie and Howe. — Bayeux, *18005*.
Lithothamnion floridanum Foslie. — Dame Marie, *17864*.
Melobesia membranacea (Esper) Lamouroux. — Dame Marie, *17819;* Les Roseaux, *17936;* Saint Louis du Sud, *17955*.

CORALLINACEAE

Amphiroa fragilissima (Linnaeus) Lamouroux. — Dame Marie, *17853;* Les Roseaux, *17943a;* Bayeux, *17992*, *18002*.
Amphiroa Hancockii Taylor (*in press*, 1942). — Bayeux, *18006*.
Amphiroa Tribulus (Ellis and Solander) Lamouroux. — Bayeux, *18009*.
Corallina cubensis (Montagne) Kützing. — Trou Cochon, *17931*.
Corallina subulata Ellis and Solander. — Les Roseaux, *17940*.
Jania adherens Lamouroux. — Les Roseaux, *17943*.
Jania rubens (Linnaeus) Lamouroux. — Dame Marie, *17851;* Trou Cochon, *17932*.

GRATELOUPIACEAE

Grateloupia filicina (Wulfen) C. Agardh. — Trou Cochon, *17916*, *17927*.

SOLIERIACEAE

Agardhiella tenera (J. Agardh) Schmitz. — Jérémie, *17869*.

HYPNEACEAE

Hypnea musciformis (Wulfen) Falkenberg. — Dame Marie, *17835;* Jérémie, *17874;* Trou Cochon, *17926;* Saint Louis du Sud, *17957;* Léogane, *17964;* Bayeux, *17995*.
Hypnea spinella (C. Agardh) Kützing. — Dame Marie, *17822;* Jérémie, *17897*.

GRACILARIACEAE

Gracilaria confervoides (Linnaeus) Greville. — Dame Marie, *17832*.

Gracilaria damaecornis J. Agardh. — Saint Louis du Sud, *17953.*
Gracilaria ferox J. Agardh. — Bayeux, *17988.*
Gracilaria foliifera (Forsskål) Børgesen. — Dame Marie, *17827;* Les Roseaux, *17937;* Saint Louis du Sud, *17954.*
Gracilaria mamillaris (Montagne) Howe. — Jérémie, *17870.*

GIGARTINACEAE

Gigartina acicularis (Wulfen) Lamouroux. — Jérémie, *17900.*

RHODYMENIACEAE

Coelothrix irregularis (Harvey) Børgesen. — Dame Marie, *17839;* Bayeux, *17974.*

CERAMIACEAE

Centroceras clavulatum (C. Agardh) Kützing. — Les Roseaux, *17842;* Jérémie, *17868;* Trou Cochon, *17928;* Saint Louis du Sud, *17958.*
Ceramium nitens (C. Agardh) J. Agardh. — Dame Marie, *17836;* Jérémie, *17892.*
Ceramium subtile J. Agardh. — Jérémie, *17871.*
Spermothamnion gorgoneum (Montagne) Bornet. — Les Roseaux, *17949.*
Spyridia filamentosa (Wulfen) Harvey. — Dame Marie, *17826;* Bayeux, *17994.*

RHODOMELACEAE

Acanthophora muscoides (Linnaeus) Bory. — Jérémie, *17866;* Trou Cochon, *17925.*
Acanthophora spicifera (Vahl) Børgesen. — Dame Marie, *17830;* Léogane, *17963;* Bayeux, *17991.*
Amansia multifida Lamouroux. — Trou Cochon, *17914;* Les Roseaux, *17938.*
Bostrychia Binderi Harvey. — Trou Cochon, *17919* (det. C. K. Tseng).
Bryothamnion Seaforthii (Turner) Kützing. — Dame Marie, *17825;* Trou Cochon, *17921.*
Bryothamnion triquetrum (Gmelin) Howe. — Trou Cochon, *17925;* Les Roseaux, *17944;* Bayeux, *17980.*
Digenia simplex (Wulfen) C. Agardh. — Jérémie, *17895.*

Heterosiphonia Wurdemanni (Bailey) Falkenberg. — Dame Marie, *17820.*

Laurencia obtusa (Hudson) Lamouroux. — Bayeux, *17971.*

Laurencia papillosa (Forsskål) Greville. — Dame Marie, *17849;* Jérémie, *17901;* Saint Louis du Sud, *17951;* Bayeux, *17981.*

Lophosiphonia obscura (C. Agardh) Falkenberg. — Trou Cochon, *17904.*

Polysiphonia ferulacea Suhr. — Trou Cochon, *17915.*

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PLATES I–IV

FIG. 1. *Gelidiella trinitatensis*, sp. nov. × 10
FIG. 2. *Gloiophlaea caribaea*, sp. nov. × 2

FIG. 1. *Gelidium crinale* (Turner) Lamouroux var. *platycladum*, var. nov., tetrasporic. × 1.2

FIG. 2. *Pterocladia capillacea* (Gmelin) Bornet & Flahault. × 0.9 (from specimens in the Herbarium of the New York Botanical Garden)

FIG. 1. *Gelidium floridanum*, sp. nov., cystocarpic. × 0.9
FIG. 2. *Gelidium floridanum*, sp. nov., tetrasporic. × 0.9
(From specimens in the Herbarium of the New York Botanical Garden)

FIG. 1. *Pterocladia americana*, sp. nov. × 1.2 (from a specimen in the Herbarium of the New York Botanical Garden)

FIG. 2. *Pterocladia Bartlettii*, sp. nov. × 0.8

MARINE ALGAE OF HONG KONG. III
THE GENUS BOSTRYCHIA *

CHENG KWEI TSENG

BOSTRYCHIA Montagne (1842) is a genus of small algae generally at least partly dorsiventral and decumbent. The frond is filamentous, mostly distichously, sometimes quite irregularly, branched, and often with inrolled apices. The filament is subcylindrical or compressed, polysiphonous, consisting of a central siphon surrounded by several rows of pericentral cells which may be naked (ecorticate) or covered with from one to several layers of smaller rectangular cells (corticate), which thus form a somewhat parenchymatous cortex. After being divided vertically from the central siphon cell, the pericentral cell so produced always divides again, by means of a horizontal wall, to form two cells. Therefore it results that there are two pericentral cells to each central siphon cell; in other words, the central cells are twice as long as the pericentral. In some species, however, one or both of the pericentral cells formed by the horizontal division divide once or twice more, thus producing from three to six pericentral cells in each central one. The behavior in this respect seems to be invariable in each particular species, which warrants its application in the classification of the genus. The number of rows of pericentral cells, on the contrary, is not constant, varying from five to ten in the lower part of the thallus and gradually decreasing upward until the ultimate ramuli, or at least their apical portions, are more or less monosiphonous. Members of this genus generally bear, besides the primary holdfasts, a number of accessory attaching organs, the haptera. These are either "cladohaptera," modified branches or branchlets occurring at regular and definite positions, or "peripherohaptera," proliferations from the pericentral cells issuing irregularly anywhere, mainly at or near the point of the branching. Tetrasporangia are tetrahedrally divided and

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are found in swollen fusiform terminal stichidia in a double row. Cystocarps are terminal on the branchlets, generally ovate, with distinct apical ostioles. Spermatangia are formed on the swollen ends of the ultimate branchlets.

Members of this genus are generally dull blackish or livid purple. They inhabit salt marshes, mangrove swamps, and brackish waters at the estuaries of rivers and streams, or even truly fresh waters far away from the seas, and grow on mud-covered rocks or the stems and roots of mangroves and other seed-bearing plants in the littoral region, or sometimes even far above high-water mark, where they are reached only by occasional splashes of waves. They prefer sheltered places and are sometimes found inside caves, pendent from the roofs, where it is dim and dark.

In describing the genus Bostrychia, Montagne (1842, p. 39) cites two species: *Rhodomela scorpioides* Ag. and *R. calamistrata* Mont. The type of the first species came from Selsey, England, and was originally described as *Fucus scorpioides* Gmel.; that of the second species came from Cuba, in the West Indies. Since the genus was published in a book dealing with the natural history of Cuba, it would seem that what Montagne had in mind as the type of the genus was *Rhodomela calamistrata* Mont. (now regarded as synonymous with *Bostrychia tenella* (Vahl) J. Ag.), which he himself described a few years earlier, rather than the English species. A great many species have been added to Montagne's genus since its publication, and up to quite recently over forty were recognized and accepted by contemporary phycologists. In 1936 Miss Post published a thorough revision of the whole genus and, having studied all the type or authentic specimens (except one type specimen which could not be located and is regarded as lost) of these species, came to the conclusion that only eleven were to be accepted as valid and either reduced the rest to synonymy or placed them in the status of varieties or forms in the accepted species. She also published at that time a manuscript species of Grunow and a new species of her own. In 1939 she issued another new one. An additional species is described in the present article, making a total of fifteen species known to date.

The naming and classification of members of this genus had for a long time been a difficult matter because of the wide distribution of most of the species and, consequently, their great variability. In her recent revision Post was able to clear up the whole situation,

after having studied, as mentioned above, the type or authentic specimens of the various proposed species as well as a great abundance of new material from diverse parts of the world. Determination of species of Bostrychia is now a much easier task. Briefly, the important characteristics are: the nature of the haptera, the cortication of the thallus, the presence or absence of the long and the dwarf shoots as well as of the normal monosiphonous branchlets, and the relative lengths of the central siphon and the pericentral cells.

Two species of Bostrychia have previously been reported from the Hong Kong region, namely, *B. Binderi* Harv. (Post, 1936, p. 31) and *B. tenella* (Vahl) J. Ag. (Post, 1937, p. 12). Both records were based on the present writer's collections, the first on specimens from Cheungchau (*Tseng 228*) and Stanley Bay (*Tseng 626*, *678*) and the second on material found sparsely intermingled with the *B. Binderi* from Cheungchau (*Tseng 228a*). So far as the entire China coast is concerned, *B. Binderi* has also been recorded from Tonghu, Swatow (*Tseng 549*), and Tsingyu, Haitan I., Fukien (*Tseng 1784*), and *B. tenella* has been recorded from Kwannan, Wenchang, Hainan (*Tseng 757*). Another species, *B. kelanensis* Grun., was later reported from Seaotan, Amoy (Post, 1939, p. 154), the record being based on *Tseng 2575a*, which contained material of the species mixed up with Caloglossa.

The writer and his helper have recently assembled ten more collections, besides several fragments of these plants intermingled with various other algae, from the Hong Kong region. A detailed study of these materials shows the presence of five more species, including a new one (see p. 171). The following analytic key serves to distinguish the species now found to occur in this region:

A. Haptera modified branchlets (cladohaptera), issuing regularly
  B. Frond without a special short trunklike axis; two pericentral cells longitudinally to each central siphon cell; pericentral cells elongate-rectangular, longer than broad ..... 1. *B. radicans*, p. 168
  B. Frond with a special short but well-developed trunklike axis; three pericentral cells longitudinally to each central siphon cell; pericentral cells quadrate to subquadrate, generally shorter than broad 2. *B. kelanensis*, p. 169
A. Haptera not modified branchlets (peripherohaptera), issuing irregularly
  B. Frond ecorticate, delicate
    C. Two pericentral cells longitudinally to each central siphon cell
      D. Frond with regular monosiphonous ramuli and more abundant branching; filaments large, to 150 μ in diameter 3. *B. hongkongensis*, p. 171

D. Frond without monosiphonous ramuli and showing rather scanty branching; filaments smaller, to 90 μ in diameter
4. *B. simpliciuscula*, p. 173
C. From four to six pericentral cells longitudinally to each central siphon cell ..... 5. *B. intricata*, p. 174
B. Frond corticated, robust
C. Ultimate ramuli with abundant regular truly monosiphonous filaments, 24–30 μ in diameter ..... 6. *B. tenella*, p. 176
C. Ultimate ramuli polysiphonous throughout or with a few irregular proliferated monosiphonous filaments, 15–18 μ in diameter
7. *B. Binderi*, p. 177

1. *Bostrychia radicans* (Mont.) Mont.

(Plate I, Figures 1–3)

In Kützing, Species algarum, 1849, p. 839, Tabulae phycologicae, XV, 1865, pl. 20, figs. a–c; Montagne, Cryptogamia Guyanensis, 1850, p. 286; J. Agardh, Species . . . algarum, II (3), 1863, p. 856; Falkenberg, Rhodomelaceen, 1901, p. 513, pl. 12, fig. 4; De Toni, Sylloge algarum, IV (3), 1903, p. 1156; Post, Notizen, 1936, p. 13; Børgesen, *Catenella Nipae* Used as Food, 1938, p. 267, fig. 3.

Rhodomela radicans Montagne, Plantes cellulaires, II, 1840, p. 198, pl. 5, fig. 3.

Bostrychia Leprieurii Montagne, Cryptogamia Guyanensis, 1850, p. 287; J. Agardh, *loc. cit.;* Kützing, Tabulae phycologicae, XV, 1865, pl. 23, figs. a–c; De Toni, *op. cit.*, p. 1150.

Polysiphonia spinescens Montagne, Cryptogamia Guyanensis, 1850, p. 289.

Bostrychia rivularis Harvey, Nereis Boreali-Americana, II, 1853, p. 57, pl. 14 D; J. Agardh, *op. cit.*, p. 955; Kützing, Tabulae phycologicae, XV, 1865, pl. 22, figs. d–g; Falkenberg, *op. cit.*, p. 514, pl. 14, fig. 18; De Toni, *op. cit.*, p. 1157.

Polysiphonia bostrychiodes Montagne, Plantes cellulaires, VIII, 1859, p. 175.

Bostrychia glomerata J. Agardh, *op. cit.*, p. 859; De Toni, *op. cit.*, p. 1152.

B. bipinnata Harvey ex J. Agardh, *op. cit.*, p. 860.

B. polysiphonioides Crouan, in Schramm et Mazé, Algues de la Guadeloupe, 1865, p. 25.

B. guadelupensis Crouan, in Schramm et Mazé, *op. cit.*, p. 26; De Toni, *op. cit.*, p. 1169.

B. fulcrata Zanardini, Phycearum Indicarum, 1872, p. 136, pl. 4 A, figs. 1–5; De Toni, *op. cit.*, p. 1149.

Frond dull purplish violet, diffuse, tufted, about 1.5 cm. high, composed of well-developed, irregularly branched, flexuous creeping stoloniferous filaments from which the erect branches are evolved. Numerous strong discoid holdfasts emitted by the stout reflexed filaments. Erect branches distichously branched, rather sparsely and irregularly pinnately decompound (see Pl. I, Fig. 1). Main axis somewhat flexuous. Branches largest in the middle, up to 240 μ in diameter, tapering toward both extremities, sometimes, for instance, measuring 90 μ in the lower basal portion, gradually increasing to 170 μ in the middle and then decreasing again to 90 μ at the apical part.

Filaments ecorticate and polysiphonous throughout. Pericentral cells elongate-rectangular in surface view, about 1.5–2.0 times longer than broad; in longitudinal view two to each central siphon cell (see Pl. I, Fig. 2); in transverse section various in number, from eight to six in the main branches, decreasing to four in the branchlets. Ultimate branchlets all more or less incurved. Accessory attachment organs of the cladohapteron type, consisting at the ends of bundles of rhizoids, regularly developed from the basal branchlets of the branches (see Pl. I, Fig. 3). Tetrasporangia developed from the terminal branchlets.

Habitat. — On littoral mud-covered rocks in sheltered mangrove swamp: Shatin, Tide Cove, in May (*Tseng 2790a*) associated with *Bostrychia kelanensis*); Aberdeen, Hong Kong I., in July (*Taam 152c*, chiefly associated with *Caloglossa Leprieurii*).

Distribution. — Sinnamary, French Guiana, northern South America (type locality); widely distributed in tropical and subtropical waters.

The Hong Kong plants, according to the description above, belong to f. *depauperata* Post.

2. *Bostrychia kelanensis* Grun.

(Plate II, Figures 1–5)

In Post, Notizen, 1936, p. 20.

Frond purplish violet, attached by a stout broad discoid holdfast, with a characteristically stout thick "trunk" as much as 0.4 mm. in diameter and 0.8 mm. high, which is several times thicker than the main branches that arise from it distichously when young (see Pl. II, Fig. 1) and spirally when older. One or more of the main branches extending horizontally to serve as stolons and at some distance from the mother plant fixing themselves on the substratum and each producing a trunklike axis, from which branches issue similarly. Repetition of this process resulting in a diffuse loose tuft, each individual, however, being distinct because of the presence of the trunk. Main branches regularly and repeatedly subdichotomously branched in one plane. Mature and better-developed fronds generally quite regularly decompound-subpinnate, with a strongly flexuous axis. Branches about 150 μ in diameter near the trunk and gradually becoming smaller until about 60 μ in diameter near the apices. Ac-

cessory attachment organs of the cladohapteron type, bearing rhizoidal filaments at the apices of the branches. Filaments ecorticate, polysiphonous throughout and distinctly articulate. Articulations very short, generally from 2.5 to 3.0 times shorter than broad. Pericentral cells nearly quadrate or shorter than broad, varying from eight in the lower part to four near the apices (see Pl. II, Fig. 2), three longitudinally to each central siphon cell (see Pl. II, Fig. 3). Tetrasporangial stichidia fusiform, much swollen, terminal at the branches, about 180 μ broad and 0.60–0.72 mm. long (see Pl. II, Fig. 4). Tetrasporangia about 60 μ in diameter.

f. **elegans,** f. nov.

Planta a forma typica differt frondibus alterne copiose decomposito-subpinnatis, ramulis ultimis plerumque apice in haptera transformatis.

Specimen typicum: *Taam A152a* (in herbario auctoris), ad rupes argillosas litoreas prope Aberdeen, Hong Kong I., 16 Jul., 1941.

Habitat. — On trunks and roots of mangroves in the littoral region, Shatin, Tide Cove, in April (*Tseng 2756*). On sheltered mud-covered littoral rocks in mangrove swamp: Shatin, Kowloon, in April (*Tseng 2727b*, associated mainly with Caloglossa) and May (*Tseng 2787a*, associated mainly with Catenella, and *Tseng 2790*); Aberdeen, Hong Kong I., in April (*Tseng 2702*) and July (*Tseng 2575e* and *Taam A152a*, TYPE of f. *elegans*, both associated chiefly with Caloglossa).

Distribution. — Kelana, New Zealand (type locality of the species); Amoy, China; widely distributed in the Indo-Pacific regions.

In the original description *Bostrychia kelanensis* Grun. is characterized by "inferne irregulariter et subfasciculatim ramosis, ramis subsimplicibus vel parce divisis . . . ." It is evident, therefore, that the type belongs to the *depauperata* form, with irregular and very few branches, corresponding to the forms *genuina* of *B. simpliciuscula*, *inermis* of *B. intricata*, and so on. This original form of Grunow's the writer proposes to call f. **typica,** nom. nov. The Hong Kong plant, f. *elegans*, on the other hand, is regularly and quite richly branched, and, when fully developed, forms haptera at the ends of most branchlets (see Pl. II, Fig. 5), thus corresponding to what Post calls f. *hapteromanica* of *B. radicans*.

The present species is certainly very distinctive and can be easily recognized by the following characteristics: the presence of an erect stout thick trunklike axis, the cladohapteron type of accessory holdfast, the very short articulations, with quadrate to subquadrate pericentral cells, and the one-to-three ratio of the length of the pericentral cells to that of the central siphon cell. The last characteristic is especially outstanding, the only other species credited with a similar ratio being *Bostrychia tangatensis* Post (1939, p. 152). The latter species, however, has an entirely different kind of haptera, the peripheral type, and lacks the characteristic trunklike axis of the present species. *B. kelanensis* is usually found intermingled with *B. intricata*, which also has short pericentral cells. That species differs from this one distinctly in having peripherohaptera and from four to six pericentral cells longitudinally to each central siphon cell, in lacking the trunklike axis, and in the parenchymatous appearance of the nonarticulated filaments in surface view. At first the writer was rather suspicious that the difference between the three and the four–six pericentral cells longitudinally to each central cell might be a mere matter of the stage of development. A study of numerous specimens revealed, however, that this ratio is quite constant, even in very young portions. Besides, though both species have short pericentral cells, those of *B. kelanensis* are generally squarish, whereas those of *B. intricata* are much shorter, usually half as high as broad. The present species is, moreover, a much more delicate plant.

3. **Bostrychia hongkongensis**, sp. nov.

(Plate III)

Frons rubropurpurea, ca. 20 mm. alta, caespitosa, diffusa, intricata, aut omnino alterne distiche decomposito-pinnata aut inferne subfurcata, superne subpinnata, articulata, ecorticata; ramis principalibus usque ad 150 μ latis, polysiphoniis cellulis pericentralibus instructis; cellulis pericentralibus sterilibus in segmenta duo transversaliter subdivisis, i.e. cellulis axilibus quam pericentralibus duplo longioribus; ramulis ultimis cum pinnulis monosiphoniis alternis instructis; fulcris flagelliformibus irregulariter dispositis prope rachidem orientibus. Stichidia, cystocarpia, et spermatangia ignota.

Specimen typicum: *Tseng 2716* (in herbario auctoris), ad rupes argillosas litoreas prope Saiwan, Hong Kong I., 11 Apr., 1940. Duplicum in Herb. Univ. Mich.

Frond reddish purple, intricately caespitose, up to 20 mm. high. Branching alternate, distichous, irregularly subpinnately decompound, sometimes subfurcate below (see Pl. III, Fig. 1). Filaments articulate and ecorticate throughout. Main branches as much as 150 μ in diameter, polysiphonous, each consisting of a central siphon surrounded generally by six pericentral cells which decrease upward to four. Pericentral cells in surface view elongate-rectangular, generally about twice as long as broad, two longitudinally to each central cell (see Pl. III, Figs. 3–4). Articulations usually slightly shorter than the diameter. Ultimate branchlet consisting of a polysiphonous base with a few simple or slightly branched, subcorymbosely disposed, monosiphonous filaments (Pl. III, Figs. 3 4). Cells of these filaments rectangular, a little longer than broad, slightly constricted at the transverse walls, about 45 μ in diameter in the lower part, decreasing gradually to about 30 μ in diameter at the tips. Haptera of the peripheral type, issuing irregularly, frequently occurring, however, at or near the points where branching takes place, formed by proliferations from the pericentral cells (see Pl. III, Fig. 2). All materials collected were sterile.

Habitat. — Forming intricate mass on sheltered littoral mud-covered rocks, Saiwan, Hong Kong I., in April (*Tseng 2716*, TYPE; *Tseng 2712a*, intermingled with *Bostrychia tenella* and *B. simpliciuscula*). On sandy loam in mangrove swamp at high-tide mark, Taipa I., Macao, in April (*Tseng 2720*).

The present species is characterized by the distinctly articulate ecorticate frond with longitudinally elongated pericentral cells, of which there are two to each central cell, by peripherohaptera, and by regular, normal, monosiphonous ramuli. Its nearest relative is undoubtedly *Bostrychia simpliciuscula* Harv. (= *B. tenuis* Post), which is sometimes found intermixed in the same tuft and which differs from the present species in the absence of monosiphonous filaments, the thallus being polysiphonous throughout. *B. simpliciuscula* is much slenderer, also, being generally only half as broad as the present species. The relationship between the two is somewhat similar to that between *B. tenella* and *B. Binderi*, as well as to that between *B. Moritziana* and *B. radicans*. The profusely branched ecorticate frond with monosiphonous branchlets in the present species reminds one very much of *B. Moritziana;* the latter species, however, has the cladohapteron type of accessory holdfast and a more robust

frond, with more abundant monosiphonous filaments. In the combinations of characteristics of specific value by Post (1939, p. 153) the present species belongs to the hypothetical species No. 3.

4. *Bostrychia simpliciuscula* Harv. ex J. Ag.

(Plate II, Figures 6–7)

J. Agardh, Species . . . algarum, II (3), 1863, p. 854; Falkenberg, Rhodomelaceen, 1901, p. 512; De Toni, Sylloge algarum, IV (3), 1903, p. 1155; Harvey, Friendly Islands Algae no. 23 (nomen subnudum).

Bostrychia rivularis Harvey, Phycologia Australica, III, 1860, pl. 176 B (non *B. rivularis* Harvey, Nereis Boreali-Americana, II, 1853, p. 57, pl. 14 D).

B. Andoi Okamura, Icones of Japanese Algae, I (5), 1907, p. 102, pl. 22, figs. 14–22.

B. tenuis Post, Notizen, 1936, p. 22.

Frond intricate, rather scantily and irregularly branched, with branches of the neighboring orders differing only slightly in diameter (see Pl. II, Fig. 6). Branches about 60–90 μ in diameter near the base, very gradually attenuated upward to 30–40 μ in diameter at the tips, generally about 55–65 μ in diameter for the larger part of the frond. Filaments ecorticate and polysiphonous throughout except in the tips, where they may remain monosiphonous for a short distance. Pericentral cells generally in four rows in the erect branches and in five or six rows in the creeping ones, two longitudinally to each central siphon cell, in surface view about 1.2–1.5 times longer than broad. Peripherohaptera issuing irregularly and giving rise to elongate rhizoidal filaments about 18–20 μ in diameter (see Pl. II, Fig. 7). Plants reddish purple.

Habitat. — On littoral muddy rocks in sheltered salt marsh: Saiwan, Hong Kong I., in April (*Tseng 2712a*, associated mainly with *Bostrychia tenella*, but also with *B. hongkongensis*); Shatin, Tide Cove, in July (*Taam A146a*, associated with *B. Binderi*).

Distribution. — Friendly Is. (type locality), East Africa, Riukiu Is., Australia, New Zealand, Chile.

From the synonyms listed above, it is clear that Post is not justified in proposing the new name *Bostrychia tenuis* merely because the two earlier valid names, *B. simpliciuscula* and *B. Andoi*, do not refer to the "typical" form of the species. Whether the form represented by "*B. rivularis*" Harv. from Australia (1860) or that represented by *B. simpliciuscula* and *B. Andoi* is typical is subject to differences of opinion, and technically, nomenclaturally, the two

latter names have priority so far as the species itself is concerned. The name *B. simpliciuscula* Harv. ex J. Ag. should therefore be used for this particular species, and it follows, in a technical sense, which may or may not agree with the true natural state, that the irregularly and sparsely branched form *is* the *typical* form, for which the writer proposes the form name f. **genuina,** nom. nov. (= *B. tenuis* Post, f. *simpliciuscula* (J. Ag.) Post), based on Harvey's Friendly Islands Algae no. 23. Accordingly, for the form with abundant regular distichous branches the form name f. **luxurians,** nom. nov., is proposed, based on "*B. rivularis*" Harv. (1860, pl. 176 B), which is *B. tenuis* Post f. *typica* Post.

The present species is closely related to *Bostrychia hongkongensis* Tseng, as was mentioned under that species. They resemble each other in the ecorticate frond with similarly shaped pericentral cells, in the ratio between the length of these cells and that of the central siphon cells, and in the kind of haptera. *B. simpliciuscula* differs, however, from *B. hongkongensis* in the absence of truly monosiphonous filaments, in the scanty irregular branching, with the branches of the various orders more equal in diameter, and in the much thinner filaments. On the basis of these conspicuous differences the two species, although sometimes occurring in the same tuft, can readily be distinguished from each other.

5. *Bostrychia intricata* (Bory) Mont.

(Plate I, Figures 4–5)

Montagne, Diagnoses phycologicae, 1852, p. 317; J. Agardh, Species . . . algarum, II (3), 1863, p. 866; Kützing, Tabulae phycologicae, XV, 1865, p. 23, figs. d–f; De Toni, Sylloge algarum, IV (3), 1903, p. 1166.

Scytosiphon intricatum Bory, in Dumont d'Urville, Flore des Malouines, 1826, no. 8 bis (nomen nudum).

Scytonema intricata Bory, Cryptogamie, in Duperrey, Voyage autour du monde, 1829, p. 225.

Bostrychia Hookeri Harvey, in Hooker f. and Harvey, Algae Antarcticae, 1845, p. 269; Harvey, Nereis Australis, 1847, p. 69; Kützing, Species algarum, 1849, p. 840, Tabulae phycologicae, XV, 1865, pl. 21, figs. a–c; J. Agardh, *op. cit.*, p. 857; Falkenberg, Rhodomelaceen, 1901, p. 509, pl. 11, figs. 19–24; De Toni, *op. cit.*, p. 1148.

B. fastigiata Harvey, in Hooker f. and Harvey, *loc. cit.;* Harvey, *loc. cit.;* Kützing, Species algarum, 1849, p. 840; J. Agardh, *op. cit.*, p. 857; De Toni, *op. cit.*, p. 1151.

B. mixta Hooker f. et Harvey, *op. cit.*, p. 270; Harvey, *op. cit.*, p. 70, Phycologia Australica, III, 1860, pl. 176 A; Kützing, Species algarum, 1849, p. 840, Tabulae phycologicae, XV, 1865, pl. 20, figs. d–f; J. Agardh, *op. cit.*, p. 858;

Falkenberg, *op. cit.*, p. 511; De Toni, *op. cit.*, p. 1150; Post, Notizen, 1936, p. 39.

B. Laingii J. Agardh, Analecta algologica, IV, 1897, p. 72; De Toni, *op. cit.*, p. 1151.

Frond about 12 mm. high, sparingly, distantly, and subdichotomously branched (see Pl. I, Fig. 4). Branches up to 240 μ in diameter in the lower portions, attenuated upward to 40–60 μ in diameter at the apices. Terminal segments subulate, more or less incurved. Filaments ecorticate, polysiphonous, and inarticulate throughout. Pericentral cells in surface view subquadrate to almost hexagonal, about one third to one half shorter than broad; from four to six longitudinally to each central siphon cell (see Pl. I, Fig. 5). Haptera of the peripheral type, formed at irregular intervals (see Pl. I, Fig. 4). Tetrasporangial stichidia terminal and much swollen.

Habitat. — Intermingled with various mangrove-swamp algae on mud-covered littoral rocks: Saiwan, in April (*Tseng 2712f*, with *Bostrychia tenella* and other algae), and Aberdeen, in July (*Tseng 2575a* and *Taam A152b*, both associated with *Caloglossa Leprieurii*), both on Hong Kong I.; Taipa I., Macao, in April (*Tseng 2719b*, with *C. Leprieurii*, and *Tseng 2720a*, with *B. hongkongensis*).

Distribution. — Falklands Is., subantarctic South America (type locality); widely distributed in the subantarctic regions and in the warmer seas.

This is a very common alga in the mangrove swamps of this region. So far, however, it has never been found in the pure condition or as the dominant element of a tuft or a patch. Instead, it always occurs intermingled, as a minor constituent, with other algae. The Hong Kong plant, as seen from the description above, belongs to f. **inermis** (Post), comb. nov. (*Bostrychia mixta* f. *inermis* Post).

In discussing the right specific epithet to apply to the present species Post (1936, p. 39) selected *Bostrychia mixta* Hook. f. et Harv., presumably on the basis of priority. A little checking of the synonyms listed above, however, shows clearly that there were three valid names published ahead of *B. mixta*. The specific epithet *intricata* first appeared in Dumont d'Urville's *Flore des Malouines* (1826), in the name "*Scytosiphon intricatum* Bory"; since there is no accompanying description, this must be regarded as a *nomen nudum*. Three years later Bory validly published the same plants under *Scytonema intricatum*. Bory based his species on two specimens;

of these, according to Post, who has studied both, the Falklands specimen belongs here, whereas the Chilean specimen is referred to *B. scorpioides* Mont. Post (1936, p. 36) in the list of synonyms of the latter species makes this remark: "*Scytonema intricata.* 'Chili,' leg. D.-J. Durville, Herb. Rostoc. (d. Typus von den Falklands ist dagegen *B. mixta!*)." To be sure, Bory did not designate either of the two specimens as the type. Nevertheless, since he was the one who named the Falklands plant *Scytosiphon intricatum* in d'Urville's *Flore des Malouines*, since this was the first plant mentioned in his *Scytonema intricatum*, and since the descriptions both of Bory and of Montagne, who transferred it to Bostrychia, apply better to the present species, it is clear that the specific name *intricata* must be applied to the Falkland specimen, not to the Chilean. Post, also, regards the former as the type of *Scytonema intricatum* Bory. It follows, therefore, that the correct name to apply to this plant is *B. intricata* (Bory) Mont.

Even if it can be proved that the specific epithet *intricata* cannot be used for this species, there are still two other valid names, *Bostrychia Hookeri* Harv. and *B. fastigiata* Harv. These, together with *B. mixta* Hook. f. et Harv., are all published in the same paper, but they have priority of place (one page ahead) and thus invalidate the last name. Post mentioned another synonym also, *Fucus exilis* of R. Brown, 1801, which is evidently a manuscript name, for it is not found in any of the standard works, such as Turner's *Fuci* and the treatises of C. Agardh, J. Agardh, Kützing, and De Toni.

6. *Bostrychia tenella* (Vahl) J. Ag.

(Plate I, Figure 6)

J. Agardh, Species . . . algarum, II (3), 1863, p. 869; Falkenberg, Rhodomelaceen, 1901, p. 515, pl. 12, figs. 10–13; De Toni, Sylloge algarum, IV (3), 1903, p. 1162; Okamura, Icones of Japanese Algae, I (5), 1907, p. 96, pl. 22, figs. 1–13; Howe, Algae, in Britton, Flora of Bermuda, 1918, p. 523; Børgesen, Marine Algae of the Danish West Indies, II, 1920, p. 300; Post, Notizen, 1936, p. 25.

Fucus tenellus Vahl, Kryptogamiske Planter fra St. Croix, 1802, p. 45.

Rhodomela calamistrata Montagne, Plantes cellulaires, 1837, p. 354.

Bostrychia calamistrata (Mont.) Montagne, Plantes cellulaires . . . Cuba, 1842, p. 39, pl. 4, fig. 1 a–g; Kützing, Species algarum, 1849, p. 839, Tabulae phycologicae, XV, 1865, pl. 19, figs. a–c; Harvey, Nereis Boreali-Americana, II, 1853, p. 56, pl. 14 C.

B. elegans Crouan, in Schramm et Mazé, Algues de la Guadeloupe, 1865, p. 25.

B. muscoides Crouan, *loc. cit.*

B. pilifera Kützing, Tabulae phycologicae, XV, 1865, pl. 25, figs. d–f.

Frond forming extensive prostrate intricate patches, with its branches overlapping each other, dorsiventral, distichously pinnately decompound. Main axis about 2–3 cm. long, twice or thrice pinnately branched. Branches either elongated and indefinite (long shoots) or short and definite (dwarf shoots). Ultimate branchlets terminating in simple or branched monosiphonous filaments which may consist of as many as 40 cells. These cells slightly barrel-shaped, about 24–30 μ in diameter and longer than broad, slightly broader below, attenuated toward the apices (see Pl. I, Fig. 6). Main axis, principal branches, and thicker branchlets all corticated, the corticating cells 30–45 μ in diameter. Pericentral cells in transverse section from six to seven, giving rise to the few layers of cortical cells; in longitudinal section two to each central siphon cell. Peripherohaptera issuing irregularly. Tetrasporangial stichidia cylindrical-rostrate to lanceolate, up to 150 μ in diameter and 800 μ long. Plants brownish purple and rather soft.

Habitat. — Pendent on the roof of a cavern, high above the highest water mark, Cheungchau, in October (*Tseng 228a*, associated with *Bostrychia Binderi*). On sheltered mud-covered littoral rocks: Aberdeen, in April (*Tseng 2705a*, associated with Boodleopsis), and Saiwan, in April (*Tseng 2712*), both on Hong Kong I.; Clear Water Bay, Port Shelter, in March (*Tseng 2683*).

Distribution. — St. Croix, West Indies (type locality); Hong Kong and Hainan, China; widely distributed in tropical and subtropical waters.

7. *Bostrychia Binderi* Harv.

(Plate I, Figures 7–8)

Harvey, Nereis Australis, 1847, p. 68, pl. 28; J. Agardh, Species . . . algarum, II (3), 1863, p. 873; Falkenberg, Rhodomelaceen, 1901, p. 521; De Toni, Sylloge algarum, IV (3), 1903, p. 1166; Post, Notizen, 1936, p. 28.

Bostrychia sertularia Montagne, Plantes cellulaires, VIII, 1859, p. 176; Howe, Algae, in Britton, Flora of Bermuda, 1918, p. 523.

B. tenella var. *terrestris* J. Agardh, *op. cit.*, p. 869.

B. Vieillardi Kützing, Tabulae phycologicae, XV, 1865, p. 10, pl. 26, figs. a–e.

B. Mazei Crouan, in Schramm et Mazé, Algues de la Guadeloupe, 1865, p. 26.

B. capillacea Crouan, in Mazé et Schramm, Algues de la Guadeloupe, 2d ed., 1877, p. 254.

Amphibia pectinata (Kütz.) Howe, Algae, in Britton and Millspaugh, Bahama Flora, 1920, p. 573.

Frond forming densely crowded extensive prostrate intricate mats, with its branches overlapping each other, dorsiventral, distichously

pinnately decompound, with both long and dwarf shoots and irregularly disposed peripheral haptera. Ultimate branchlets typically short, spinelike, and polysiphonous throughout, sometimes, under certain environmental conditions, proliferating shorter or longer monosiphonous filaments, which generally consist of only a few cells, but occasionally of as many as twenty-five. These filaments to some extent superficially simulating the truly monosiphonous branchlets of the previous species, but always confined to the last order of the branching system, or to only a part of it, and having then a polysiphonous base (see Pl. I, Fig. 8); cylindrical throughout, without any sign of constriction; cells small, about 15–18 μ in diameter and about as long as broad; sometimes colorless in the terminal part, resembling very much the rhizoidal filaments issuing from the haptera. Branches of all orders corticated and polysiphonous throughout except in the monosiphonous proliferations mentioned above. Corticating cells about 15–20 μ in diameter. Pericentral cells from six to seven in transverse section, two longitudinally to each axial siphon cell. Tetrasporangial stichidia varying in shape from ovoid and shortly cylindrical-clavate to elongate-cylindrical-rostrate, about 150–180 μ in diameter and from two to five times as long. Apex obtuse, acute, or apiculate, or even with a branchlet above (see Pl. I, Fig. 7). Plants generally violet or brownish purple.

Habitat. — (1) The shade plants: Cape d'Aguilar, in March (*Tseng 2686*), and Stanley Bay, in June (*Tseng 2650*), both on Hong Kong I.; Clear Water Bay, Port Shelter, in May (*Tseng 2804*); Cheungchau, in October (*Tseng 228*, with *Bostrychia tenella* as a minor constituent of the patch). (2) The light plants: Stanley Bay, in March (*Tseng 626, 678*), and Aberdeen, in April (*Tseng 2705b*, associated with Boodleopsis and *Bostrychia tenella*), both on Hong Kong I.; Shatin, Tide Cove, in May (*Tseng 2793*) and July (*Taam A146*); Clear Water Bay, Port Shelter, in March (*Tseng 2683a*, associated with *Bostrychia tenella*).

Distribution. — Port Natal (type locality); Hong Kong, Swatow, and Hainan, China; widely distributed in tropical and warmer seas.

The plants collected in the Hong Kong region all come near to f. *typica* Post. They can, however, be further separated into two groups, as has been done under "Habitat" above, depending upon the amount of light they receive. One group, as represented by *Tseng 228*, include slenderer and softer plants found pendent on the roofs

of caverns very far above high-tide mark, where they received very little light. These have been called "shade plants," and they are usually violet purple. They used to be called *Bostrychia sertularia* Mont., which is now regarded as a synonym of the present species. The other group, as represented by *Tseng 626*, have a much more robust and rigid frond and occur on muddy rocks in the littoral region, where they are exposed to strong light. These have been called "light plants," and are usually brownish purple. They were formerly known as *Amphibia pectinata* (Kütz.) Howe, which is also now synonymous with *B. Binderi*. Both forms are found in sheltered places; the writer has never collected any where the current is strong and the rocks exposed and clean.

The present species and *Bostrychia tenella* certainly resemble each other very much in several characteristics. Consequently, there has been a controversy as to whether they should be kept separate or should be united into one species, one being made a variety, or even a form, of the other. Howe (1918, 1920) was probably the first to study critically the differences between these two groups. He tried to distinguish them on the basis of (1) the number and relative length of the monosiphonous cells, (2) the shape and relative length of the stichidia, and (3) the color of the frond. With regard to the number of monosiphonous filaments, although it is true that *B. tenella* has many more cells than *B. Binderi*, this factor, if taken alone, is too arbitrary, and not always reliable. In fact, this difference has been too much emphasized and forms the center of the controversy. Again, the relative length of these filaments, whether longer than broad, or vice versa, is also not always constant in each species. That the monosiphonous cells of *B. tenella* are longer than those of *B. Binderi* is quite true, but this is due to the fact that *B. tenella* has larger cells, 25–30 μ in diameter, whereas those of *B. Binderi* are only 15–18 μ in diameter. With regard to the stichidia, they are more constant in shape and comparatively long in *B. tenella* and very variable and comparatively short in the present species. Moreover, those of the former species are always terminal, whereas those of the latter may be terminal and subterminal, since the apical portion often grows into a branch again. As for the color of the frond, it varies according to external conditions and so is certainly not a good criterion specifically.

Quite recently Post (1938) discussed the differences between these

two species, emphasizing (1) the difference between primary and secondary monosiphony, and (2) the occurrence of both species in the same tuft. The writer, also, has studied many living collections of these species and is in perfect agreement with Post. It is clear from an evolutionary and ecological point of view that there must be two species rather than one and a variety since both plants grow in the same tuft and hence under exactly the same ecological conditions; the belief that one is an ecological form or geographical variety of the other is, therefore, without foundation. As regards the monosiphony, what Post takes as "primary" is what the writer would call "true" monosiphony, which occurs regularly, whatever the ecological conditions, and which is typical of *Bostrychia tenella*. The present species, however, has only "secondary" monosiphony, which is irregular and is what the writer would regard merely as "proliferation"; it is formed only under certain ecological conditions, for instance, under the stimulus of very muddy and unfavorable situations. These proliferated monosiphonous filaments not uncommonly have the upper parts irregularly curled and more or less decolorized, so that they resemble very much the rhizoidal filaments issuing from the haptera.

Besides the differences brought to light by Howe and Post, it may be remarked that *Bostrychia tenella* has larger and more or less barrel-shaped monosiphonous cells and larger cortical cells. With all these differences on hand, there can be no further difficulty in distinguishing one species from the other. The following table summarizes the characteristics discussed above:

TABLE I

Comparison of Bostrychia tenella and B. Binderi

	B. tenella	*B. Binderi*
Monosiphony	Primary or true, natural	Secondary or proliferated, ecological
Monosiphonous cells	More or less constricted at transverse wall, all colored, 24–30 μ in diameter	Cylindrical throughout, terminal ones sometimes colorless, 15–18 μ in diameter
Cortical cells	35–40 μ in diameter	15–20 μ in diameter
Stichidia	More regularly shaped, always terminal, from four to ten times longer than broad	Variously shaped, terminal or subterminal, from two to five times longer than broad

SUMMARY

Seven species of Bostrychia, including one new one, have been found in the Hong Kong region. *B. hongkongensis*, sp. nov., is closely related to *B. simpliciuscula* Harv. ex J. Ag., differing in the presence of monosiphonous filaments, in the larger diameter, and in the more regular and abundant branching. *B. radicans* (Mont.) Mont., *B. simpliciuscula* Harv. ex J. Ag., and *B. intricata* (Bory) Mont. are here recorded for the first time for this region as well as for China as a whole. *B. kelanensis* has previously been reported from Amoy and is now added to the flora of Hong Kong. *B. tenella* and *B. Binderi* were already known to occur in this region; a critical comparative study has been made of these two closely related and long-disputed species to determine the fundamental and important differences between them.

The writer wishes to thank Professor Wm. Randolph Taylor, of the University of Michigan, for his advice in preparing the present study.

University of Michigan

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EXPLANATION OF PLATE I

FIG. 1. *Bostrychia radicans* (Mont.) Mont. f. *depauperata* Post. Habit sketch of a tetrasporic plant. × 10

FIG. 2. *B. radicans* (Mont.) Mont. f. *depauperata* Post. Lengthwise section of a filament, showing pericentral and axial siphon cells. × 142

FIG. 3. *B. radicans* (Mont.) Mont. f. *depauperata* Post. Upper part of a branch, showing haptera. × 20

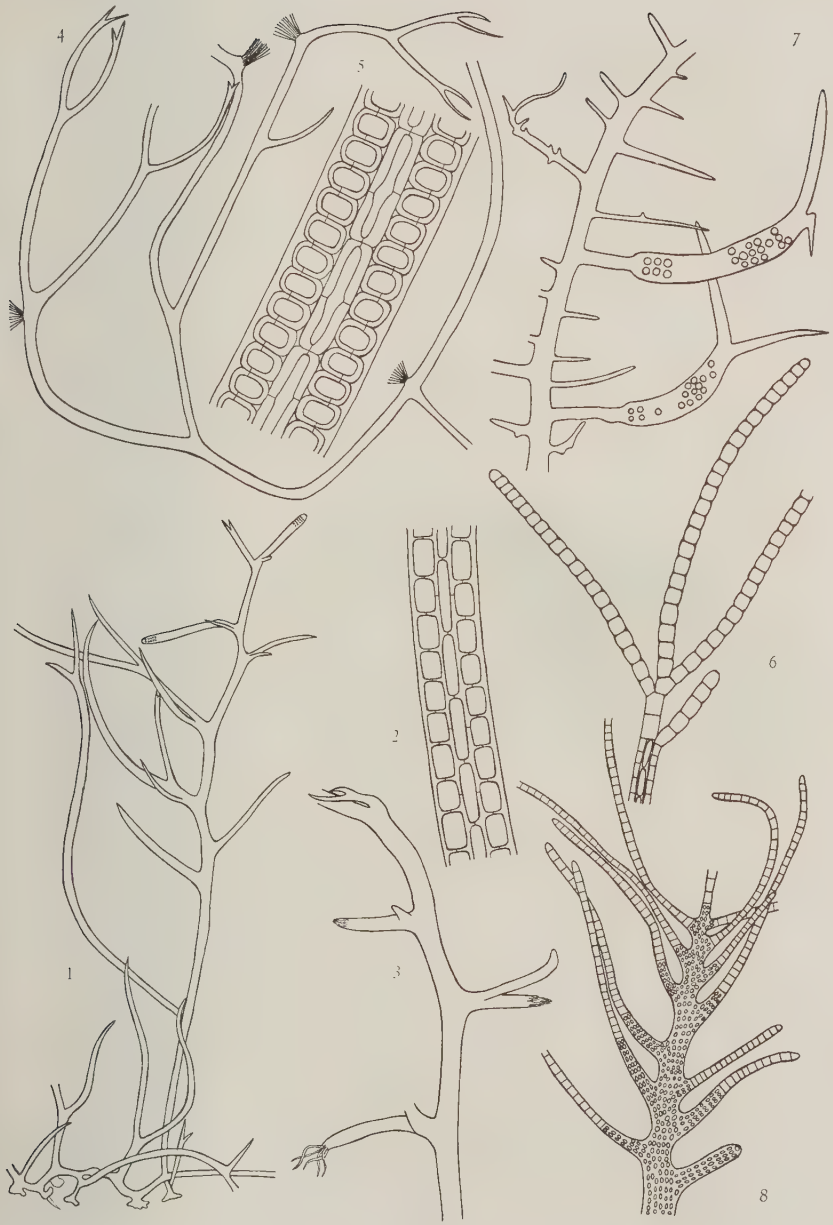
FIG. 4. *B. intricata* (Bory) Mont. f. *inermis* (Post) Tseng. Habit sketch of part of a frond, showing branching and haptera. × 10

FIG. 5. *B. intricata* (Bory) Mont. f. *inermis* (Post) Tseng. Lengthwise section of a filament, showing pericentral and axial siphon cells. × 142

FIG. 6. *B. tenella* (Vahl) J. Ag. Branchlet, showing monosiphonous filaments. × 71

FIG. 7. *B. Binderi* Harv. Part of a frond, showing branching and tetrasporangial stichidia. × 20

FIG. 8. *B. Binderi* Harv. Upper part of a frond, showing branching and proliferated monosiphonous filaments. × 71



Marine algae of the genus Bostrychia

EXPLANATION OF PLATE II

FIG. 1. *Bostrychia kelanensis* Grun. f. *elegans*, f. nov. Habit sketch of a young plant. × 10

FIG. 2. *B. kelanensis* Grun. f. *elegans*, f. nov. Transverse section of a filament. × 68

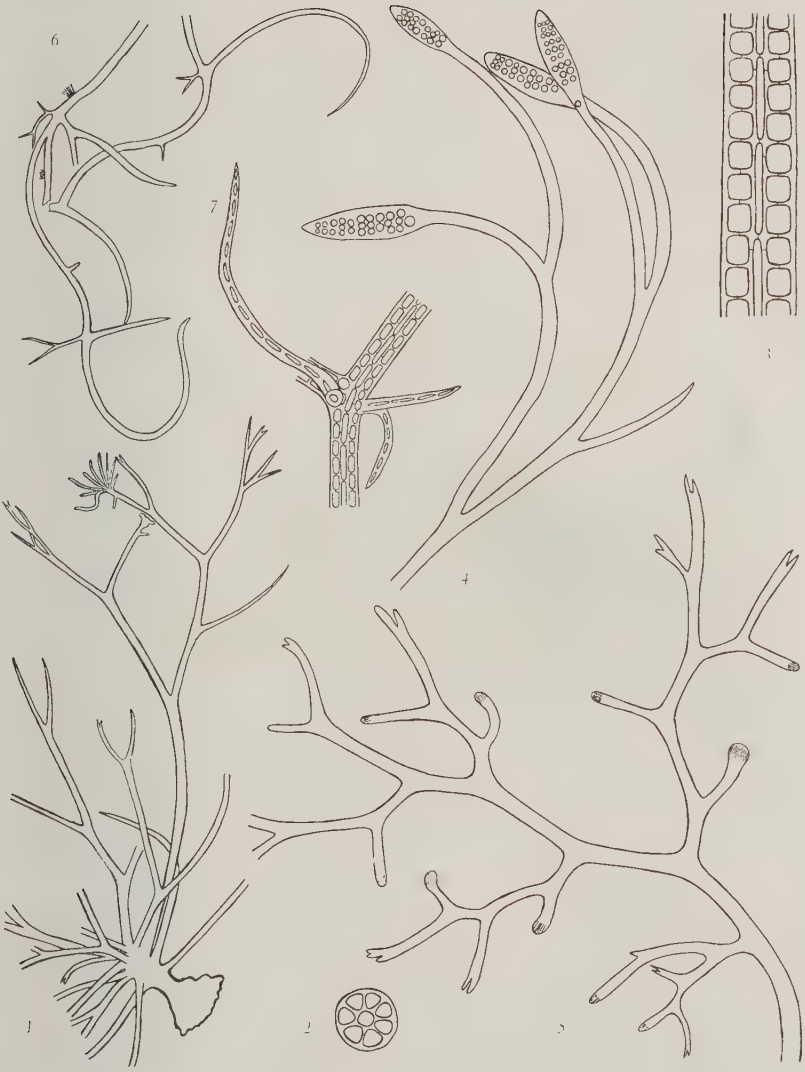
FIG. 3. *B. kelanensis* Grun. f. *elegans*, f. nov. Lengthwise section of a filament, showing pericentral and axial siphon cells. × 136

FIG. 4. *B. kelanensis* Grun. f. *elegans*, f. nov. Upper part of a tetrasporic plant, showing stichidia and sporangia. × 20

FIG. 5. *B. kelanensis* Grun. f. *elegans*, f. nov. Upper part of a mature plant, showing haptera. × 20

FIG. 6. *B. simpliciuscula* Harv. ex J. Ag. Habit sketch of part of a frond, showing branching and haptera. × 15

FIG. 7. *B. simpliciuscula* Harv. ex J. Ag. Lengthwise section of a filament, showing pericentral and axial siphon cells and rhizoidal filaments. × 68



Marine algae of the genus Bostrychia

EXPLANATION OF PLATE III

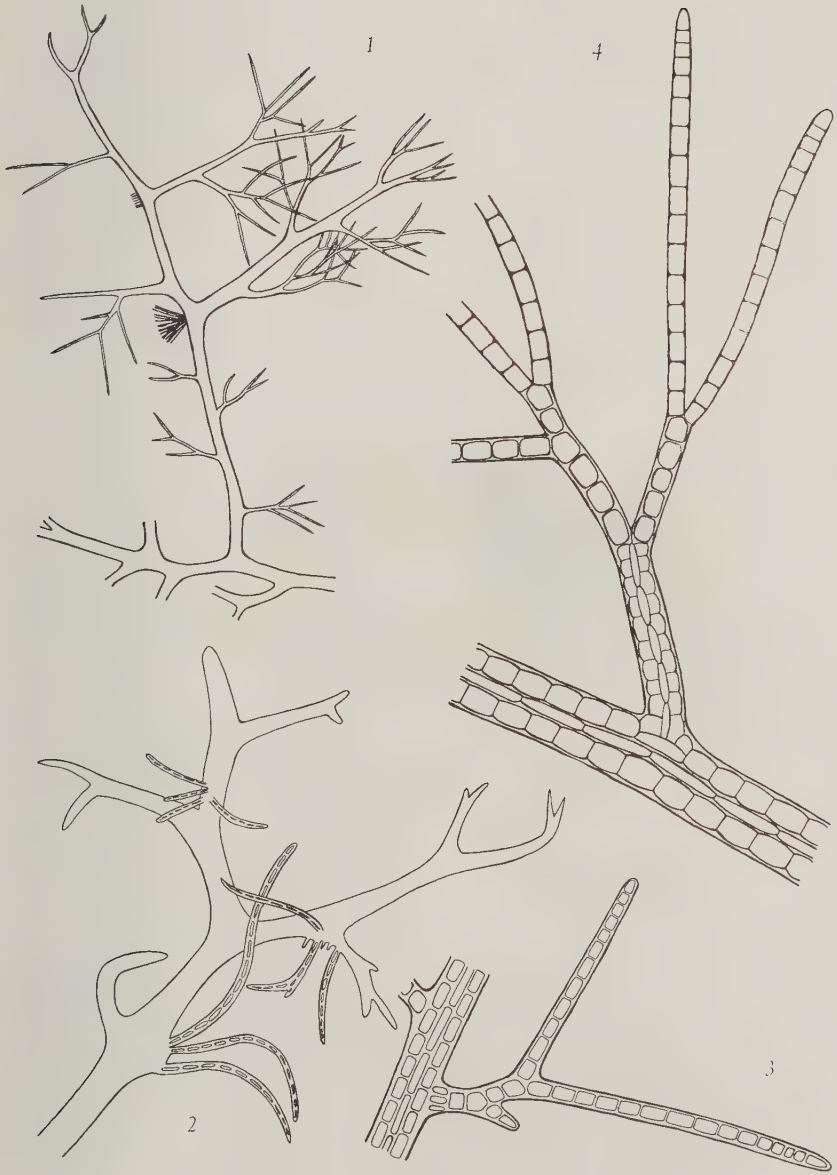
Bostrychia hongkongensis, sp. nov.

FIG. 1. Habit sketch of part of the plant, showing branching. × 12

FIG. 2. Part of the plant, showing rhizoidal haptera. × 89

FIG. 3. Lengthwise sectional view of part of a young branch, showing the pericentral and axial siphon cells and monosiphonous filament. × 89

FIG. 4. Lengthwise sectional view of part of an older branch, showing a monosiphonous branchlet. × 89



Marine algae of the genus Bostrychia

MARINE ALGAE OF HONG KONG. IV
THE GENUS LAURENCIA *

CHENG KWEI TSENG

THE genus Laurencia is a group of generally medium-sized, firmly fleshy or cartilaginous, variously colored "red" algae of tropical and the warmer temperate waters. The fronds are erect and repeatedly pinnately or paniculately branched, sometimes subdichotomous, with terete or compressed branches. They are radially organized, with each axis composed of an axial siphon surrounded by from four to six rows of pericentral cells, which give rise to a rather thick compact parenchymatous cortex with a layer of surface cells. The axis, though fundamentally polysiphonous in structure, is obscure, being visible only at the apices of the branches. As a result, the axial cells and the cortical cells are not clearly distinct from each other and are together generally called the "medulla." The "medullary" cells, in some species, have characteristic refringent lenticular thickenings of the walls. The surface cells, which may well be called "epidermal" cells, are usually hexagonal, but sometimes irregularly polygonal, in surface view. In certain species they are radially elongated and arranged more or less like the palisade cells in transverse sections of the branchlet. In others they are subquadrate or broader than long, not radially elongated nor arranged like palisade cells. The apices of the branches or branchlets are obtuse and crateriform, with apical cells which have three cutting surfaces and which are deeply sunken in the pits and protected by the trichoblasts. The tetrasporangia are tetrahedrally divided, occurring near the apices or scattered in the upper parts of ordinary branchlets or of somewhat modified stichidious ones, which may be simple or branched. They are embedded in the cortical layers and do not originate directly from the pericentral cells. The spermatangial clusters are ovoid to

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subcylindrical, often closely paniculately united and frequently sunken in the greatly enlarged and cup-shaped apical craters. The cystocarps are ovoid, subglobular, or somewhat urceolate, solitary or several crowded together, sessile on the outer surfaces of the upper ultimate branchlets.

Members of this genus are extensively distributed in warmer waters, especially in the tropics. They inhabit both shallow and deep waters, and are found in quiet sheltered spots as well as surf-beaten exposed ones. Generally they prefer places where the current is rapid and the water comparatively clear. They abound especially in tide pools, and are found on rocks, stones, or coral chips.

Most of the species are firmly fleshy to quite cartilaginous; relatively few are soft and tender. Although, compared with other members of the red seaweeds, they are usually erect medium-sized plants, some are very small and inconspicuous, creeping, and intricate, whereas others may reach a height of 30 or more centimeters. They vary a great deal in color, shading from brilliant pinkish red to dull blackish purple. Among members of the same species, however, the color is relatively constant. Some of them, especially those living in shallow waters, appear greenish to bluish.

Lamouroux (1813, p. 130), in founding the genus Laurencia, enumerated eight species, without designating any of them as the type, which is in accord with the practice of early authors. Since *L. pinnatifida* (Gmel.) Lamx., based on *Fucus pinnatifidus* Gmel. from the British Isles and France, was the first name listed, it might reasonably be considered the technical type of the genus. Schmitz and Falkenberg, however, preferred to regard the more widely distributed *L. obtusa* (Huds.) Lamx., based on *Fucus obtusus* Hudson from England, as the type. Since the publication of the genus some scores of species have been added to it. Critical systematic studies have been made by J. G. Agardh (1863, 1876) and, quite recently, by Yamada (1931). Agardh divided the genus into four sections, namely, Filiformes, Papillosae, Obtusae, and Pinnatifidae, differentiating them chiefly by the branching of the fronds and on the basis of whether these were terete or compressed. He listed thirty-eight accepted species and several "*species inquirendae.*" The Agardhian system was adopted by De Toni (1903), who accepted forty-four species, listed sixteen questionable ones, and excluded ten. In his revision of the genus Yamada emphasized the anatomical characters, es-

pecially the transverse-section view of the epidermal cells (surface cells), whether radially elongated and palisade-like or not, and the presence or absence of lenticular thickenings on the medullary cell walls. He redivided the genus, retaining but emending the section Pinnatifidae, discarding the three remaining sections suggested by J. Agardh, and proposing three other sections, namely, Palisadae, Forsterianae, and Cartilagineae. Sixty-four species were listed, including fifteen new ones, and many former species were reduced to the status of varieties or synonyms of the accepted species. Yamada had examined most of the type or authentic specimens in the various important American and European herbaria, and the results of his studies of these specimens were incorporated in the revision, making it a most valuable one. Unfortunately for phycologists who have not had access to these type specimens, the author did not publish enough details (especially microscopic characters and measurements, as well as details concerning the structure of reproductive organs) to give them a sufficiently clear and definite idea about many of the species or to clarify his interpretation of them. Some published species and varieties and some specimens distributed in important exsiccatae were also disregarded, which makes their status questionable. "*Laurencia paniculata*" (no. 21 of Okamura's *Algae Japonicae Exsiccatae*), for instance, which is apparently not that species but probably near to *L. glandulifera* Kütz., was not dealt with at all.

Since the appearance of Yamada's revision twelve more species have been published by various authors (Yamada, one; Børgesen, three; Howe, two; Howe and Taylor, one; and Setchell and Gardner, five), bringing the total number of accepted species to seventy-six. In general the taxonomy of the genus is now based mainly on such external morphological characters as the branching of the frond, the terete or compressed state of the branches, and the tetrasporiferous branchlets, and on the internal anatomy.

No Laurencia species has hitherto been reported from the Hong Kong region. From other parts of the China coast the following six are already known: *L. obtusa* (Huds.) Lamx. and *L. venusta* Yam. from Peitaiho, *L. capituliformis* Yam. from Tengchoufou, *L. intermedia* Yam. from Tengchoufou and Tsingtao, *L. Okamurai* Yam. from Peitaiho and Amoy, and *L. papillosa* (Forssk.) Grev. from Tsingtao and Amoy. It is to be noted that the records of "*L. papillosa*" are probably erroneous, at least those reported by the present

writer; but since the specimens on which these records were based are not available now, it is not possible to correct the identifications at this time. In the past few years the writer and his assistants have assembled about 150 different collections of Laurencia from the various parts of the China coast. Of these, about one third came from the Hong Kong region. Although it is the author's intention to report his study of all of these collections in the near future, the twelve species from the Hong Kong area will be discussed in this paper first, for they represent very interesting plants, eight of which have not hitherto been described. The fact that these new species are mostly small and inconspicuous probably explains why they have not been reported previously. The writer would not be surprised if they should eventually be found to be common in the nearby regions, especially those bordering the South China Sea. The following key serves to distinguish the Hong Kong Laurenciae from each other:

A. Frond simple or furcate ..... 10. *L. subsimplex*, p. 202
A. Frond repeatedly and profusely branched
  B. Frond with branches decidedly compressed and distichous except near tips and base
    C. Frond small, as much as 4 cm. high and 2 mm. broad, cartilaginous; epidermal cells projecting near ends of branchlets; margin of fertile branches not undulate ..... 11. *L. parvipapillata*, p. 204
    C. Frond larger, as much as 7 cm. high and 4 mm. broad, fleshy; epidermal cells not projecting; margin of fertile branches undulate ..... 12. *L. undulata*, p. 206
  B. Frond with branches generally cylindrical or slightly compressed and polystichous
    C. Epidermal cells elongated radially, arranged like palisade cells in transverse section of branchlets
      D. Branches crowded near apex, with subflabellately cymose or irregularly digitate closely set branchlets more or less in two ranks ..... 4. *L. longicaulis*, p. 194
      D. Branches more loosely and evenly disposed, with irregularly set branchlets in more than two ranks
        E. Ultimate branchlets turbinate, strongly swollen at tips, crowded on minor branches ..... 1. *L. jejuna*, p. 189
        E. Ultimate branchlets subcylindrical or subclavate, more loosely disposed on minor branches
          F. Ultimate branchlets longer, up to 3 mm. or more in length, lower ones several times longer than upper ones ..... 3. *L. surculigera*, p. 192
          F. Ultimate branchlets very short, about 1 mm. long, all of approximately the same length 2. *L. paniculata*, p. 191
    C. Epidermal cells neither elongated radially nor arranged like palisade cells in transverse section of branchlets

D. Frond small, about 1.0 cm. high and 0.5 mm. in diameter, very soft and slender, repeatedly subflabellately dichotomous or subdichotomous; tetrasporangia on ultimate segments of all branches and branchlets ..... 9. *L. tenera*, p. 200

D. Frond larger, 2.5 cm. or more high, 1 mm. or more in diameter, firmer and more robust, pinnately branched; tetrasporangia only on ultimate branchlets

E. Frond a beautiful pinkish red; epidermal cells projecting more or less at ends of branchlets; medullary cell walls without lenticular thickenings 8. *L. obtusa* var. *majuscula*, p. 200

E. Frond brownish red to dark purple; epidermal cells not projecting; medullary cell walls with lenticular thickenings

F. Frond small, about 2.5 cm. high or less, sparsely branched, articulate here and there 5. *L. articulata*, p. 195

F. Frond large, 8–30 cm. high, profusely branched, not articulate

G. Main axis slightly compressed; principal branches issuing from all sides; branches densely covered with ultimate branchlets ..... 6. *L. japonica*, p. 197

G. Main axis strongly compressed; principal branches apparently distichous; branches covered loosely with ultimate branchlets .... 7. *L. chinensis*, p. 198

1. **Laurencia jejuna**, sp. nov.

(Plate I, Figures 1–3)

Frons fuscopurpurea, ca. 3 cm. alta, substantia firma, dense caespitosa, discis ad saxum adfixa; ramis principalibus teretibus, usque ad 1.1 mm. diam., e trunco brevi orientibus, erectis vel aliquando arcuatis, inferne plerumque annulose articulatis, subnudis, mox laxe alternate vel opposite subpinnate decompositis; ramulis ultimis distichis vel tristichis, juventate subcylindricis, aetate clavatis vel turbinatis, ad apicem capitatis vel tuberculosis, fertilibus simplicibus ad apicem valde inflatis vel lobatis, aut a verrucis multis (2–5) irregulariter tectis; in sectione transversali cellulis epidermalibus plus minusve valliformibus, radialiter elongatis, 15–20 μ latis, 20–35 μ altis; cellularum medullosarum parietibus incrassationibus lenticularibus aut annularibus saepe instructis; tetrasporangiis sphaericis, ca. 120 μ diam., in ramulorum ultimorum apicibus sitis; cystocarpiis urceolatis, usque ad 0.9 mm. latis, 1.3 mm. longis, in ramulo sessilibus. Acervuli spermatangiales ignoti. Species *Laurenciae papillosae* (Forssk.) Grev. proxima videtur.

Specimen typicum: *Tseng 2565* (in herbario auctoris), ad rupes zonae inferioris litoralis, prope Shek-O, Hong Kong I., 15 Jul., 1937.

Frond tufted, about 3 cm. high, attached by a discoid holdfast, dark purple, firmly subcartilaginous. Principal branches arising from a well-developed short thickish trunk, terete, up to 1.1 mm. in diameter, erect or sometimes arcuate, often annulate-articulate and sparsely branched below, loosely alternately or oppositely subpinnately decompound above (see Pl. I, Fig. 1). Ultimate branchlets distichous or tristichous, subcylindrical when young and clavate to turbinate with capitate or tuberculate apices when older; when fertile, either simple and greatly inflated or lobed at the apices, or irregularly covered with from two to five warts, which are rounded at the tips and attenuated at the bases (see Pl. I, Fig. 1). Epidermal cells in transverse section of the branchlets palisade-like, radially elongated, about 15–20 μ broad and 20–35 μ high, with thick walls (see Pl. I, Fig. 3). Medullary cells with very thick walls, often with lenticular, arcuate, or annulate thickenings. Tetrasporangia spherical, up to 120 μ in diameter, situated at the much-swollen apices of the ultimate branchlets, which may be simple or give rise to from two to five warts, thus becoming more or less compound. Cystocarps urceolate, as much as 0.9 mm. broad and 1.3 mm. long, including a neck about 0.2–0.3 mm. long, generally solitary and sessile on the minor branches, together with one or two sterile branchlets (see Pl. I, Fig. 2). Spermatangia not found.

Habitat. — On littoral rocks and in rock pools: Repulse Bay, in May (*Tseng 2799*), Big Wave Bay, in June (*Tseng 2852*), and Shek-O, in July (*Tseng 2565*, TYPE), all on Hong Kong I.; Potaiau, Kowloon, in July (*Taam A142*).

The inclusion of *Tseng 2799* in this species is made with some reservation. It is a slightly larger plant (to 4 cm. high and 1.3 mm. in diameter, is more profusely branched than the type collection, and has no articulation. Otherwise it agrees quite well with the species.

This new species is undoubtedly closely related to the presumably widely distributed *Laurencia papillosa* (Forssk.) Grev., originally described from the Red Sea, but now reported from almost everywhere in tropical and subtropical waters. The differences are chiefly in the disposition of the branchlets, which in the Red Sea plant are densely crowded and from four- to many-ranked; in the anatomy

of the frond, which in that species has very strongly radially elongated epidermal cells and medullary cell walls without any lenticular thickenings; and in the disposition of the cystocarps, many of which are crowded on the same branchlet in *L. papillosa*. The latter species is also noted for its rigid thallus, almost coriaceous when dried, and its often greenish to yellowish purple color, which is not true of *L. jejuna*. As its name indicates, the Hong Kong species is a diminutive plant, reaching full maturity, with both sexual and asexual organs, when only 3 cm. high. Its annular articulations and sometimes arcuate branches with unilaterally disposed branchlets, well exhibited in the type collection, also help to characterize this species.

2. *Laurencia paniculata* (C. Ag.) J. Ag.

J. Agardh, Species . . . algarum, II (3), 1863, p. 755, III, 1876, p. 651; De Toni, Sylloge algarum, IV (3), 1903, p. 788; Yamada, Notes on Laurencia, 1931, p. 192, pl. 3, fig. a; Børgesen, Marine Algae . . . Iranian Gulf, 1939, p. 119, fig. 33.

Chondria obtusa var. *paniculata* C. Agardh, Species algarum, I (2), 1822, p. 343.

Laurencia thuyoides Kützing, Tabulae phycologicae, XV, 1865, pl. 74, figs. a–b.

Frond tufted, attached by discoid holdfasts, about 5 cm. high, irregularly paniculately decompound. Branches of all orders terete, up to 1.8 mm. in diameter, subfastigiate below and more divaricate above, the primary ones up to 2.5 cm. long. Ultimate branchlets generally shortly clavate, sometimes turbinate or wartlike, about 1 mm. long, issuing in various directions on the minor branches. Epidermal cells angularly subrotund in surface view and more or less palisade-like in transverse section, 15 30 μ broad and 25–45 μ high; more elongated radially and more distinctly palisade-like, from two to three times longer than broad in sections near the apices, and broader, about from one and one half to two times higher than broad, in sections lower down in the branchlets; subquadrate, almost as broad as high, in sections of the branches and main axis. Medullary cell walls very much thickened, sometimes with what appear to be lenticular thickenings, which are, however, not refringent. Tetrasporangia about 90 μ in diameter when mature, situated very near the apices of the ultimate branchlets, often in rather regular rings. Fertile branchlets simple toward the apices of the minor branches and somewhat branched lower down, as are the sterile ones. Young cystocarps urceolate, sessile on much-shortened branchlets, in groups of from two to five, issuing in all directions. Spermatangia not found. Plants

firm and subcartilaginous, dull reddish purple when living, turning grayish purple when dried.

Habitat. — On littoral rocks and in rock pools between tide marks: Shek-O, Hong Kong I., from April to May (*Tseng 2562*, *Taam A92*); Lunghawan, Port Shelter, in May (*Tseng 2580*); Pakpai I., near Putoi I., in May (*Taam A112*); Lamma I., in May (*Taam A120*).

Distribution. — Adriatic Sea (type region), Mediterranean Sea, Iranian Gulf, New Caledonia.

The writer is not entirely without hesitation in identifying the Hong Kong plants with the Adriatic species. They agree quite well with the description by J. Agardh and the photograph of the type specimen published by Yamada (1931). They do not resemble, however, the "*Laurencia paniculata*" of the American phycologists — for instance, Phycotheca-Boreali-Americana, no. 1093, and specimens identified with it by Farlow, Collins, and others. Though Yamada (*loc. cit.*) made known the characteristics of the type specimen, he did not, unfortunately for phycologists, clear up the status of these various specimens, currently known under this supposedly cosmopolitan species, or that of the Japanese specimen which appears under the same name (Okamura's Exsiccata no. 21). They seem to be heterogeneous, representing several species rather than a single one. It is very necessary, to understand the Agardhian species more definitely, that a detailed description of the macroscopic and microscopic characteristics as well as of the reproductive organs be prepared, based on the type specimen and supplementary topotype materials. The range of variation should be similarly determined. Until this information is available the writer has to be content with his present identification of the Hong Kong specimens and has to interpret *L. paniculata* rather vaguely, as a member of the section Palisadae with a firmly subcartilaginous frond, more or less paniculate branching, and very short, but rather loosely disposed, ultimate branchlets.

3. **Laurencia surculigera,** sp. nov.

(Plate I, Figures 4–5)

Frons fulvopurpurea, ca. 4.5 cm. alta, molliter carnosa, e surculis basi prostratis assurgens; surculis teretibus, discis membranaceis latis vel rhizoideis ad substratum adfixis; ramis erectis teretibus

vel leviter compressis, subpinnate decompositis, percurrentibus, usque ad 2 mm. latis, in parte media modice crassioribus quam in basi et apice attenuatis; ramulis ultimis subcylindricis vel clavatis, apice truncatis vel rotundis, usque ad 3 mm. longis, quoquoversum egredientibus, plerumque longitudine intervalla aequantibus; cellulis epidermalibus a superficie visis angulate subrotundis, parietibus tenuibus, in sectione transversali valliformibus, radialiter elongatis, 15–30 μ latis, 30–45 μ altis; cellularum medullosarum parietibus partes incrassatas lenticulatas non ostendentibus; partes aliae desunt. Species *Laurenciae perforatae* (Bory) Mont. et *L. palisadae* Yam. proxima videtur.

Specimen typicum: *Tseng 293* (in herbario auctoris), ad rupes litorales, prope Stanley Bay, Hong Kong I., 11 Apr., 1933.

Frond brownish purple, about 4.5 cm. high, softly fleshy, arising from prostrate terete surculi and attached by broadly membranaceous discoid holdfasts or by bundles or rhizoids. Erect branches terete or slightly compressed, subpinnately decompound, percurrent, up to 2 mm. broad, broadest in the middle part and attenuated more near the base and less near the tips. Primary branches, while still young, sometimes curving down toward the substratum, fixing by means of secondary holdfasts and acting as surculi, with further branching taking place secundly and dorsally (see Pl. I, Fig. 4). Ultimate branchlets subcylindrical to clavate, truncate or rounded at the apices, up to 3 mm. long, emerging in various directions although usually appearing distichous in dried specimens, mostly separated from each other by spaces subequal to their own length. Epidermal cells angulate-rounded or somewhat hexagonal, with rather thin walls in surface view, palisade-like, evidently radially elongated, 15–30 μ broad and 30–45 μ high in transverse section of the branchlets (see Pl. I, Fig. 5). Medullary cells without lenticular thickenings of the walls. All specimens collected were sterile.

Habitat. — On littoral rocks and in rock pools in rather sheltered places: Stanley Bay, Hong Kong I., in April (*Tseng 293*, TYPE); Putoi I., in April (*Tseng 2747*).

This new species is a member of the section Palisadae, closely related to *Laurencia perforata* (Bory) Mont. from the Canary Islands, on the one hand, and to *L. palisada* Yam. from Formosa, on the other. It resembles the Canary Islands alga in the presence of the curved branches and secund branchlets, which, however, occur

much more frequently in the latter species. *L. perforata* is, moreover, a much smaller plant, with rather scanty branching and more predominantly decumbent habit. The disposition of the ultimate branchlets in *L. surculigera* is similar to that in *L. palisada*, which, however, has a distinct thickish stem from which several primary branches arise. In addition, the Formosan species does not appear to have surculi. The present species differs from *L. paniculata* J. Ag. in the softly fleshy substance, the much simpler, looser, sometimes secund branching, and the presence of surculi. It must be remembered, however, that this species is founded on sterile specimens. Its actual relationship with other species can be known only when fruiting material is available.

4. **Laurencia longicaulis,** sp. nov.

(Plate II, Figures 1–2)

Frons fulvopurpurea, ca. 4.5 cm. alta, firmiter carnosa, caespitosa, discis ad saxum adfixa; ramis principalibus teretibus, usque ad 2 mm. diam., numerosis, a trunco brevi ca. 1 mm. alto orientibus, inferne longe subnudis, subsimplicibus, aliquando annulose articulatis, superne dense alternatim ramosis; ramulis ultimis clavatis, 0.50–0.65 mm. diam., pseudopolychotomose vel cymose fasciculatis, ad apicem truncatis; in sectione transversali cellulis epidermalibus evidenter radialiter elongatis, 15–18 μ latis, 30–36 μ altis, simili modo ut cellulis valliformibus dispositis; cellularum medullosarum parietibus incrassationibus lenticularibus aut annularibus saepe instructis; tetrasporangiis sphaericis, usque ad 90 μ diam., in superiore parte ramorum ramulorumque ortis. Cystocarpia et acervuli spermatangiales ignota. Species *Laurenciae flagelliferae* J. Ag. proxima videtur.

Specimen typicum: *Tseng 2579* (in herbario auctoris), ad rupes litoreas, prope Big Wave Bay, Hong Kong I., 20 Mai., 1938.

Frond yellowish purple, firmly fleshy, about 4.5 cm. high, caespitose, attached by a broad discoid holdfast and with a well-developed short thickish trunk about 1 mm. high, from which several main filaments arise. These filaments subcylindrical, attenuated below and broadening above to 2 mm. in diameter; usually with annular scars; naked and unbranched (or with only a few short branchlets below) for a distance of 15–30 cm., closely set above, near the apices, with secondary branches, which arise alternately and more or less

distichously, producing subflabellately cymose or irregularly digitate ultimate branchlets (see Pl. II, Fig. 1). These branchlets clavate and broadly truncate at the apices, about 0.50–0.65 mm. in diameter. Epidermal cells in surface view hexagonal or polygonal, 15–18 μ broad, in transverse section of the branchlets evidently radially elongated and palisade-like, 15–18 μ broad, 30–36 μ high (see Pl. II, Fig. 2). Medullary cells large, very thick walled, often with lenticular, arcuate, or annulate thickenings. Tetrasporangia spherical, up to 90 μ in diameter, scattered near the apices of the branches and branchlets. Sexual organs not found.

Habitat. — On surf-beaten littoral rocks: Big Wave Bay, in May (*Tseng 2579*, TYPE), Shek-O, in May (*Tseng 2625*), both on Hong Kong I.; Potaiau, Kowloon, in May (*Taam A103*).

The present species is certainly a very characteristic one, easily recognized and distinguished from other members of the Palisadae by its fleshy caespitose frond with a short thickish trunk which is naked and unbranched for a long distance below, then more or less densely alternately branched above, with closely set, flabellately cymose or pseudopolychotomous branchlets. It is undoubtedly most closely related to the East Indian *Laurencia flagellifera* J. Ag., which is also a member of the Palisadae and which resembles the present species in some of the characteristics mentioned above. The Indian plant, however, is a much more elegant species, from two to four times higher than the present one; it does not have the special short thickish trunk and has many fewer and much looser branchlets.

5. **Laurencia articulata,** sp. nov.

(Plate II, Figures 3–4)

Frons fuscopurpurea, ca. 2.5 cm. alta, substantia firma, laxe intricata, pro majore parte repens, discis ad saxum adfixa; ramis principalibus numerosis, e trunco brevi usque ad 2.5 mm. crasso orientibus; ramis ramulisque teretibus, 0.4–1.1 mm. latis, irregulariter distincte annulose articulatis, unilateraliter raro alternate vel opposite sparsim ramosis, in parte superiore saepe arcuatis, ad apicem plerumque haptera rhizoidea formantibus; ramulis clavatis, apice truncatis; in sectione transversali cellulis epidermalibus subquadratis, 25–30 μ diam., haud simili modo ut cellulis valliformibus dispositis, parietibus cellularum medullosarum incrassationem lenti-

culatam ostendentibus; tetrasporangiis sparsis, oblongis, usque ad 90 μ latis, 120 μ longis, in ramulis ultimis (qui sunt sterilibus similes) sitis. Cystocarpia et acervuli spermatangiales ignota. Species *Laurenciae pygmaeae* Web.–v. B. proxima videtur.

Specimen typicum: *Tseng 2561* (in herbario auctoris), ad rupes arenosas litoreas, prope Stanley Bay, Hong Kong I., 14 Jul., 1937.

Frond dark purple, firmly subcartilaginous, about 2.5 cm. high; loosely intricate, largely prostrate, attached by a discoid holdfast and with a well-developed short trunk about 2.5 mm. thick, from which several principal branches arise (see Pl. II, Fig. 3). These branches terete, 0.4–1.1 mm. broad, generally broadest in the middle part and more or less attenuated toward both ends. Annular discs found here and there irregularly but quite abundantly, the filaments thus appearing distinctly articulate (see Pl. II, Fig. 3). Branching generally unilateral, sometimes alternate or even opposite. Branches and branchlets often more or less arcuate, curving toward the substratum, upon touching which their apices are often transformed into haptera giving rise to numerous well-developed rhizoids; growth of these branches necessarily becoming definite, and secondary branches arising unilaterally from the dorsal sides. Branches clavate, truncate at the apices. Epidermal cells in transverse section of the branchlets subquadrate, 25–30 μ broad and 25–32 μ high, not radially elongated nor arranged like palisade cells (see Pl. II, Fig. 4). Lenticular thickenings present in the medullary cell walls. Tetrasporangia few, oblong, up to 120 μ long and 80–90 μ broad, developed near the apices of the ultimate branchlets. Sexual organs not found.

Habitat. — On sand-covered littoral rocks, Hong Kong I., in July: Stanley Bay (*Tseng 2561*, TYPE) and Wongmakok, Titam Peninsula (*Taam A148*).

The present species is certainly a very characteristic and easily recognizable one. It is unique in the section Forsterianae in its irregularly scattered cup-shaped annular scars, which make the filaments appear distinctly articulate, and in its arcuate branches often with apical tenaculae and unilateral dorsal branchlets. It is probably more closely related to the Malayan *Laurencia pygmaea* Web. v. B. than to other members of the section. That species, however, besides not having the unique characteristics mentioned above, is a much smaller plant, only up to 250 μ in diameter. Though annular scars have been reported in *L. flagellifera* J. Ag., *L. longi-*

caulis Tseng, and *L. jejuna* Tseng, all belonging to the section Palisadae, they are by no means so abundant or of such general occurrence in every part of the thallus in these species as in the present one. Curved branches and unilateral branching are found in a few other species, especially *L. perforata* (Bory) Mont., *L. surculigera* Tseng, and, to a lesser extent, *L. jejuna*, all of which belong to the section Palisadae, with comparatively poorly developed repent filaments. As for the presence of apical tenaculae, there seems to be no parallel with it in this genus, so far as the writer's information goes.

6. *Laurencia japonica* Yam.

Yamada, Notes on Laurencia, 1931, p. 211, fig. L, pl. 10, figs. a–b.

Frond dark purple, somewhat subcartilaginous, up to 30 cm. high, caespitose, arising from a densely intricate mass of rhizoidal or stoloniferous filaments, attached by basal discs; repeatedly irregularly pinnately branched, with longer branches below and shorter ones above, thus forming a pyramidal outline. Main axis terete when young and somewhat compressed when older, straight or slightly flexuous, broadest in the middle part, up to about 2.2 mm. in diameter, and attenuated toward both extremities. Primary branches issuing alternately or suboppositely, rather patent and open. Ultimate branchlets shortly clavate, truncate or rounded at the apices, distichous and subopposite when young, sometimes tristichous, subfastigiately and loosely disposed; more densely crowded in older branches, reminding one somewhat of *Laurencia papillosa*. Epidermal cells in transverse section of the branchlets irregularly subquadrate or slightly elongated tangentially, not arranged like palisade cells, about 20–30 μ broad and 28 30 μ high. Tetrasporangia slightly oblong, as much as 130 μ long and 120 μ broad, scattered in the stichidious branchlets, which are pinnately compound when mature. Cystocarps ovate-urceolate, up to 0.72 mm. broad and slightly longer, obliquely sessile, several crowded together on the upper part of the fertile branchlets. Spermatangia not found.

Habitat. — Abundant on rocks near the lower littoral region: White Sand Beach, Stanley, in March (*Tseng 585*), April (*Tseng 295*), and May (*Tseng 322*), Shek-O, in January (*Taam A26*), March (*Tseng 2655, Taam A73, A74*), and May (*Tseng 2626*), Cape d'Aguilar, in March (*Tseng 2697*), Repulse Bay, in May (*Tseng 2800*), Big

Wave Bay, in May (*Taam A120*), all on Hong Kong I.; Lamma I., in May (*Taam A121*); Putoi I., in June (*Tseng 2823*).

Distribution. — Amatsu and Emi, Boshu Province, Japan (type region).

Plants of *Laurencia japonica* Yam. vary a good deal upon aging, as its describer remarked. The species has previously been known only from the type region, and from there only in the original record of its occurrence, although it is, presumably, common in Japan. It is therefore interesting to find it so abundant in the Hong Kong region. It must be noted that the original description allows it a maximum height of only 8 cm., whereas the Hong Kong plants attain a height of 30 cm. In other respects, however, these plants agree well with Yamada's account. The writer, although unable to study the type or any authentic specimen, feels quite confident in making the identification.

7. **Laurencia chinensis,** sp. nov.

(Plate III, Figures 1–3)

Frons rubropurpurea, ca. 8 cm. alta, cartilaginea, e surculis prostratis assurgens; surculis teretibus, tenuibus, ca. 0.2–0.3 mm. latis, rhizoideis robustis saxo adfixis; ramis erectis ad basim teretibus, sursum mox plus minusve distincte compressis, in parte superiore et in ramulis subteretibus, duplo vel triplo pinnatim ramosis; ramis principalibus usque ad 1.2 mm. latis, percurrentibus, juventate distinctis, aetate obscuris, circumscriptione paniculiformibus vel subcorymbiformibus; ramulis ultimis subcylindricis, distichis vel tristichis, ad apicem truncatis; in sectione transversali cellulis epidermalibus subquadratis, 30–45 μ diam., haud simili modo ut cellulis valliformibus dispositis; parietibus cellularum medullosarum incrassationem lenticulatam ostendentibus; tetrasporangiis usque ad 120 μ diam., densis in apicibus ramulorum ultimorum sitis. Cystocarpia et spermatangia ignota. Species *Laurenciae japonicae* Yam. proxima videtur.

Specimen typicum: *Tseng 295a* (in herbario auctoris) ad rupes arenosas zonae inferioris litoralis, prope White Sand Beach, Stanley, Hong Kong I., 15 Apr., 1933.

Frond reddish purple, cartilaginous, up to 8 cm. high. Basal

filaments horizontally creeping, terete, slender, 0.2–0.3 mm. broad, producing rhizoids downward (see Pl. III, Fig. 1). Erect filaments abundantly pinnately decompound, terete near the base, becoming more or less distinctly compressed upward, up to 1.2 mm. broad. Main axis percurrent, generally conspicuous, at least when young, and later sometimes more or less obscured by the vigorously growing lateral branches. Outline of the frond pyramidal or corymbose-paniculate. Branches at first distinctly distichous and opposite, later more or less tristichous or polystichous because of further growth of younger branches from the same nodes; the two older, opposite, distichous branches of each node, however, always the best developed, and so causing the branching, even in mature plants, to appear superficially distichous and opposite. Ultimate branchlets subcylindrical, distichously or tristichously disposed, and truncate at the apices. Epidermal cells in transverse section of the branchlets subquadrate, 30–45 μ high and 25–45 μ broad, not radially elongated like palisade cells (see Pl. III, Fig. 2). Medullary cell with lenticular thickenings of the walls. Tetrasporangia spherical, up to 120 μ in diameter, scattered near the apices of the ultimate branchlets, which are generally simple, but sometimes branched (see Pl. III, Fig. 3). Sexual organs not found.

Habitat. — On sand-covered rocks in the lower littoral region: White Sand Beach, Stanley, in April (*Tseng 295a*, TYPE), Big Wave Bay, in March (*Taam A59*) and May (*Tseng 2576*, *Taam A122*), Wongmakok, Titam Peninsula, in May (*Taam A113*), all on Hong Kong I.; Lamma I., in May (*Tseng 2586*).

Among members of the section Forsterianae, to which it most probably belongs, the present species is unique in its distinctly and strongly compressed main axis when mature and its apparently distichous branching. In this respect it resembles members of the Pinnatifidae. The main axis is subcylindrical when young however, and the branching, though distichous at first, becomes polystichous, although quite obscurely, at last. It seems to stand between Forsterianae and Pinnatifidae, probably near *Laurencia japonica*, which is also distichous when young. That species, however, has its ultimate branchlets densely crowded when older, its axis is only very slightly compressed, and its main branches are irregularly and closely disposed.

8. *Laurencia obtusa* (Huds.) Lamx. var. *majuscula* Harv.

Harvey, Phycologia Australica. V, Synoptic Catalogue, 1863, p. xxvi, no. 309b; Yamada, Notes on Laurencia, 1931, p. 223; Børgesen, Some Indian Rhodophyceae, III, 1933, p. 135.

Frond a beautiful pinkish red, robust but soft, up to 20 cm. high, quite regularly pinnately decompound, with a percurrent axis which is straight or slightly flexuous, terete, and about 2 mm. in diameter. Branches alternate or subopposite, spirally inserted, patent, diminishing in length from base to apex, thus giving the frond a pyramidal outline. Ultimate branchlets short, clavate, obtuse at tips, and subopposite. Epidermal cells in surface view irregularly oval or subrotund, 40–60 μ in diameter, more or less projecting near the ends of the branchlets; in transverse sections irregularly subquadrate, not radially elongated like palisade cells. Medullary cells without lenticular thickenings of the walls. Tetrasporangia about 120 μ in diameter, dispersed in simple or branched subcylindrical ultimate branchlets. Cystocarps ovate-urceolate, about 1 mm. broad and slightly shorter, solitary and sessile on ultimate branchlets. Spermatangia not found.

Habitat. — On rocks in the lower littoral region or, more commonly, drifted ashore: Big Wave Bay, in May (*Tseng 2760*), and Saiwan, in June (*Tseng 2844*), both on Hong Kong I.; Panglongwan, in March (*Taam A63*), and Lunghawan, in May (*Taam A129*), both on Port Shelter.

Distribution of the variety. — Western Australia (type locality), southern Japan, India, Ceylon, Iranian Gulf.

This variety is easily distinguished from the others by the beautiful red of its elegant frond, with larger surface cells (40–60 μ in diameter) projecting at the ends of the branchlets.

9. **Laurencia tenera,** sp. nov.

(Plate I, Figure 6; Plate II, Figures 5–6)

Frons leviter fulvopurpurea, nana, ca. 1 cm. alta, tenera, mollissima, caespitosa, intricata, copiose subflabellatim subcorymbose dichotome vel subdichotome ramosa; segmentis subcylindricis, 0.5–1.5 mm. longis, 0.25–0.55 mm. diam., saepe inter se per haptera peripheralia cohaerentibus; ramulis ultimis subcylindricis vel clavatis, ad apicem late truncatis; in sectione transversali cellulis epidermali-

bus subquadratis, 20–30 μ latis, 20–28 μ altis, haud simili modo ut cellulis valliformibus dispositis; cellulis medullaribus solum ca. 45 μ latis, partem incrassatam lenticulatam ad parietem non ostendentibus; tetrasporangiis sphaericis, 75–90 μ diam., in ramis ramulisque ultimis (qui sunt sterilibus similes) sitis. Cystocarpia et acervuli spermatangiales ignota. Species *Laurenciae nanae* Howe proxima videtur.

Specimen typicum: *Tseng 2600* (in herbario auctoris), ad rupes litoreas, prope Shek-O, Hong Kong I., 16 Dec., 1938.

Frond yellowish to light brownish purple, slender, very soft and somewhat gelatinous to the touch, forming a low caespitose intricate mass about 1 cm. high; abundantly dichotomously or subdichotomously branched in a more or less flabellate and corymbose manner (see Pl. I, Fig. 6). Segments subcylindrical to clavate, 0.5–1.5 mm. long and 0.25–0.55 mm. broad, the diameter varying very slightly in the neighboring segments, often cohering to each other by means of broad peripheral haptera. Ultimate segments broadly truncate at the apices. Epidermal cells in surface view polygonal, 20–30 μ long and broad in the younger segments, becoming more elongated longitudinally, up to 45 μ, in the older ones, with thin and rather indistinct cell walls, not projecting at the ends of the branchlets; in transverse section of the branchlets quadrate to subquadrate, about 20–30 μ broad, 20–28 μ high (see Pl. II, Fig. 6). Medullary cells rather small, mostly of approximately equal size, generally about 45 μ broad, without lenticular thickenings of the walls. Tetrasporangia spherical, 75–90 μ in diameter when mature, scattered near the apices, with older ones below and younger ones above (see Pl. II, Fig. 5). Tetrasporiferous branchlets similar to the ordinary ones. Sexual organs not found.

Habitat. — On surf-beaten littoral rocks, Shek-O, Hong Kong I., in December (*Tseng 2600*, TYPE; *Taam A14*).

The present species is undoubtedly most closely related to *Laurencia nana* Howe from the Bahama Islands, and the writer was at first tempted to refer this plant there as a variety. The two are alike in the dwarf nature of the frond, the frequent occurrence of peripheral haptera uniting the neighboring segments into an intricate mass, and the characteristics of the epidermal cells in transverse section. Having studied some fragments of the type specimen of *L. nana*, however, the writer has come to the conclusion that the Hong Kong plant is distinct enough from the West Indian form to deserve an

independent specific rank. The chief differences between these two species are found in (1) the substance of the frond, which is fragile and easily broken in the Bahama plant and soft and gelatinous in the present species; (2) the branching, which is more fastigiate, with a greater tendency to unilaterality, in *L. nana,* and more open, with more flabellate and equal development on both sides of the branches, in *L. tenera;* (3) the epidermal cells in surface view, those of the former having clearly distinct thick firm cell walls and being predominantly regularly hexagonal and similarly sized throughout the frond and those of the latter being more irregularly polygonal and much more elongated longitudinally in the lower part of the branches and having thin indistinct cell walls; (4) the lenticular thickenings of the medullary cell walls, which occur in the Bahama plant (according to Howe, 1934, p. 41), but are lacking in the Hong Kong one; and (5) the size of the segments, which are narrower but longer in the former species and broader but shorter in the latter.

To a smaller extent the present species also resembles *Laurencia clarionensis* Setch. & Gardn. from Clarion Island of the Revillagigedo Group and *L. Galtsoffii* Howe from Pearl and Hermes Reef. The first of these is, however, a much smaller plant, only 150–225 μ in diameter, and the second is a much more robust one, 460–780 μ in diameter. Both have lenticular thickenings on the medullary cell walls and do not have the peripheral intersegmental tenaculae which characterize *L. nana* and the present species.

10. **Laurencia subsimplex,** sp. nov.

(Plate III, Figures 4–6)

Frons fulvorubra, ca. 3 cm. alta, gelatinose carnosa, caespitosa, e disco lato oriens, simplex vel furcata; filamentis ligulatis, subcylindricis vel compressis vel complanatis, inferne attenuatis, superne dilatatis, apice obtusis, usque ad 4 mm. latis, sine ramulis; cellulis epidermalibus a superficie visis latissime rectangularibus vel multiangulatis, 20–25 μ longis, 30–46 μ latis, in sectione transversali subquadratis vel subrotundis, 36–46 μ altis, 30–46 μ latis, haud simili modo ut cellulis valliformibus dispositis; parietibus cellularum medullosarum incrassationem lenticulatam ostendentibus; partes aliae desunt. Species affinitatis incertae, probabiliter sectionem generis novam formans.

Specimen typicum: *Tseng 2578* (in herbario auctoris), ad rupes

arenosas zonae inferioris litoralis, prope Big Wave Bay, Hong Kong I., 10 Mai., 1938.

Frond brownish red, somewhat gelatinous, very fleshy, about 3 cm. high, caespitose, arising from an extensive basal disc, which sometimes simulates a thickish rhizome. Erect filaments simple or once-furcate, ligulate, subcylindrical in some plants and compressed to strongly flattened in others, attenuated below to stalklike cylindrical parts and expanding above to strap-shaped parts; obtuse at the apices, as much as 4 mm. broad, smooth or slightly wavy at the margin, and entirely without lateral ramuli (see Pl. III, Fig. 4). Epidermal cells in surface view very broadly rectangular or polygonal, seemingly longitudinally compressed, and, superficially, arranged somewhat after the fashion of brick tiers (see Pl. III, Fig. 6), 20–25 μ long and 30–46 μ broad; in transverse section subquadrate or subrotund, 36–46 μ high and 30–46 μ broad, not radially elongated like palisade cells (see Pl. III, Fig. 5). Medullary cells occasionally with lenticular thickenings of the walls. All specimens collected were sterile.

Habitat. — On sand-covered rocks in the lower littoral region, Big Wave Bay, Hong Kong I., in April (*Taam A80*) and May (*Tseng 2578*, TYPE).

The present species is certainly unique among the members of the genus Laurencia. The somewhat gelatinous very fleshy substance of this alga reminds one greatly of members of such genera as Dumontia, in which genus the writer was first tempted to place it, before the study of its internal structure was made. The apical cell sunken in the crater-like pit, the presence of a central siphon and five pericentral cells in transverse section, and the obscure axial cells in the longitudinal section of the filament show clearly its natural place in the genus Laurencia. The simple or furcate ligulate frond without any lateral branchlet is unique, not appearing in any other member of the genus. To be sure, the specimens are young and sterile, but even the very much younger stages of other species of this genus which have a slight resemblance to the present one, *L. undulata*, for instance, show some branching in accordance with the characteristic pattern of the species. Another peculiarity of this species is the arrangement of the epidermal cells, which in surface view are longitudinally compressed, usually about twice broader than long, and arranged somewhat like layers of bricks. Generally the epidermal

cells of members of Laurencia appear hexagonal, subrotund, or polygonal, and subequal in length and breadth or, if unequal, then elongate in the direction of the axis. These peculiar characteristics of *L. subsimplex* isolate it from any of the known species and place it in a unique position. Its much broadened, sometimes compressed or flattened thallus would seem to put it in the section Pinnatifidae. Yet the occurrence of the subcylindrical thallus and the absence of lateral distichous branches make this grouping unjustified. Possibly it is related to the subdichotomous-corymbose species, especially if the tetrasporangia, when found, should be located near the apices, like those of the *Laurencia clarionensis nana–tenera–Galtsoffii* complex. It also seems to have affinities with *L. humilis* Setch. & Gardn. from Clarion Island, which, like the present species, has a caespitose very sparsely branched frond. The Clarion alga, however, is a diminutive plant (8–15 mm. high, 1–2 mm. in diameter), apparently cylindrical throughout, with epidermal cells subcircular in surface view and medullary cells without lenticular thickenings. Perhaps the Hong Kong alga belongs to a new section of its own. It may even represent an undescribed genus closely related to Laurencia. Fruiting materials, unfortunately not available at present, are needed to settle this problem.

11. **Laurencia parvipapillata,** sp. nov.

(Plate IV)

Frons obscure purpurea, ca. 4 cm. alta, cartilaginea, pulvinata, caespitosa, discis ad saxum adfixa, intricata, ad basim subteres et ca. 0.8 mm. lata, sursum mox complanata ca. 2 mm. lata, pinnate decomposita; ramis ramulisque suboppositis vel alternis, distichis, irregulariter inter se per tenacula adhaerentibus, et ad rupes per rhizoideas secondarias adfixis; ramulis ultimis breviter clavatis, apice truncatis vel leviter rotundatis; cellulis epidermalibus ad partem superiorem mammiformiter projicientibus, in sectione transversali pauce radialiter elongatis, usque ad 30 μ latis, 35 μ altis, cellulis medullaribus partem incrassatam lenticulatam ad parietem non ostendentibus; tetrasporangiis oblongis, usque ad 100 μ latis, 120 μ longis, in ramulis ultimis (qui sunt sterilibus similes) sitis, generaliter ad apicem in una serie dispositis. Cystocarpia et acervuli gametangiales ignota. Species *Laurenciae pinnatae* Yam. proxima videtur.

Specimen typicum: *Tseng 2813* (in herbario auctoris), ad rupes

zonae inferioris litoralis, prope Cape d'Aguilar, Hong Kong I., 6 Jun., 1940. Duplicum in Herb. Univ. Mich.

Frond dull purple, very cartilaginous, about 4 cm. high, pulvinately caespitose, attached by a discoid holdfast. Main axis quite terete near the very base, measuring 0.8 mm. in diameter there, then becoming broadened and compressed above, up to 2 mm. broad; pinnately decompound, with distichous alternate or subopposite branches (see Pl. IV, Fig. 1) which interlock with each other, frequently producing rhizoidal tenacula binding the neighboring segments together (see Pl. IV, Fig. 2) and forming an intricate and almost inextricable mass, which also attaches to the substratum more or less similarly by secondary rhizoids (see Pl. IV, Fig. 3). Ultimate branchlets shortly clavate, truncate, or slightly rotund at the apices. Epidermal cells in surface view generally hexagonal, about 30 μ broad, strongly mammillate and projecting at the ends of the branchlets (see Pl. IV, Figs. 4–5); in transverse section subquadrate or higher than broad, somewhat radially elongated, about 30 μ broad and 35 μ high, with cuticle about 8 μ thick and the conical papillae about 6–8 μ high (see Pl. IV, Fig. 7). Medullary cells without lenticular thickenings of the walls. Tetrasporangia oblong, about 100 μ broad and 120 μ long, very regularly arranged in a ring at the apex of the ultimate branchlet (see Pl. IV, Fig. 6). Sexual organs not found.

Habitat. — Forming an intricate pulvinate caespitose patch on surf-beaten littoral rocks: Cape d'Aguilar, in March (*Tseng 2691*) and June (*Tseng 2813*, TYPE), Repulse Bay, in May (*Tseng 2798*), Aplichau, Aberdeen, in May (*Taam A132*), all on Hong Kong I.; Lamma I., in May (*Taam A119*).

The present species is a member of the Pinnatifidae, closely related to *Laurencia pinnata* Yam., the only other species in the section having surface cells which are mammillate and which project at the ends of the branchlets. The Japanese plant, however, is several times larger than the Hong Kong alga, and entirely different in habit. It is also looser in branching than the present species and does not have the intersegmental rhizoidal tenacula so characteristic of the latter. Moreover, the frond of *L. pinnata* is soft, whereas that of the present species is firm and cartilaginous. Though both species have projecting surface cells, these are not so clear and distinct in the Japanese plant as they are in the Chinese species.

12. *Laurencia undulata* Yam.

Yamada, Notes on Laurencia, 1931, p. 243, fig. T, pl. 29, fig. a.

Frond softly fleshy, reddish brown, complanate, about 7 cm. high, caespitose, arising from a basal discoid holdfast and sparsely pinnately branched. Branches distichous, with rounded axis, attenuated below and expanding upward to about 4 mm. broad. Ultimate branchlets alternate or subopposite, also distichous, and truncate or rotund at the apices, curving slightly upward. Epidermal cells in transverse section irregularly subquadrate, 20–30 μ broad, 26–36 μ long, slightly radially elongated. Medullary cells rather thick-walled, sometimes with annular thickenings. Tetrasporangia oblong, up to 110 μ broad and 160 μ long, situated near the apices of the short stichidious branchlets, which are numerous and crowded on the margin of the minor branches and so form a verrucose ruffled outline. Tetrasporiferous branchlets at times issuing in various directions from the fertile branches, thus producing a very irregular complicated outline and, sometimes, an almost subglobular mass. Sexual organs not found.

Habitat. — In tufts on rocks in the lower littoral region, Hong Kong I.: Stanley Bay, in April (*Tseng 294*), Cape d'Aguilar, in March (*Tseng 2698*), Shek-O, in March (*Taam A72*) and April (*Taam A89*).

Distribution. — Enoshima, Japan (type locality).

The writer compared his material with an authentic specimen identified by Yamada and found that they agree perfectly.

SUMMARY

Fifty-two collections of members of the genus Laurencia from the Hong Kong region have been studied, and were found to belong to twelve species, eight of which are here described for the first time. Of these eight new species, three belong to the section Palisadae, namely, *L. jejuna*, *L. surculigera*, and *L. longicaulis;* two to the section Forsterianae, namely, *L. articulata* and *L. chinensis;* one, *L. tenera*, to the section Cartilagineae; and one, *L. parvipapillata*, to the section Pinnatifidae. The affinities of the remaining new species, *L. subsimplex*, are obscure; it probably belongs by itself in an as yet undescribed section. These eight species are mostly small and inconspicuous, and may eventually be found rather widely in the

South China Sea region, rather than being limited to such a small area as Hong Kong Island and its close vicinity. Of the remaining four species, two were previously known only from the original localities in Japan; these are *L. japonica* and *L. undulata*. Another, *L. paniculata*, is more widely distributed. These three species are recorded here for the first time for the Hong Kong region, and for China, as well. The twelfth species, *L. obtusa*, has been reported from North China under one of its many varieties, var. *intricata;* the particular variety found in the Hong Kong region is var. *majuscula*, originally reported from Australian waters and now added to the floristic list of China as well as that of Hong Kong.

The writer wishes to express his thanks to Professors Wm. Randolph Taylor and H. H. Bartlett, of the University of Michigan, for their advice and help in this study, and to Dr. F. J. Seaver, Curator of Cryptogams of the New York Botanical Garden, who kindly sent specimens of various species of Laurencia needed in this research.

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EXPLANATION OF PLATE I

Fig. 1. *Laurencia jejuna*, sp. nov. Habit sketch of a tetrasporic plant, showing the branching and the tetrasporiferous branchlets. × 4

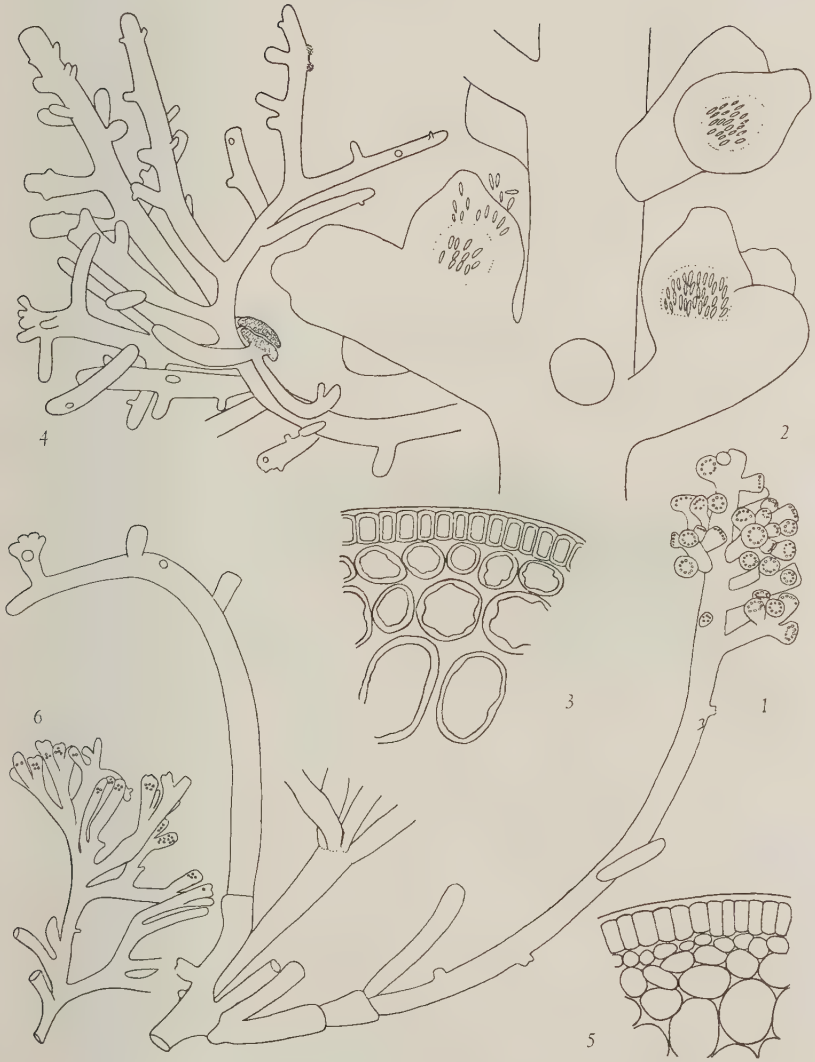
Fig. 2. *L. jejuna*, sp. nov. A part of a fertile branch with cystocarps. × 19

Fig. 3. *L. jejuna*, sp. nov. Transverse section of a branchlet. × 170

Fig. 4. *L. surculigera*, sp. nov. Habit sketch of a young plant, showing the branching and the repent filaments with holdfasts. × 3

Fig. 5. *L. surculigera*, sp. nov. Transverse section of a branchlet. × 110

Fig. 6. *L. tenera*, sp. nov. Habit sketch of a part of a tetrasporic plant, showing the branching and the tetrasporiferous branchlets. × 4



Marine algae of the genus Laurencia

EXPLANATION OF PLATE II

FIG. 1. *Laurencia longicaulis*, sp. nov. Habit sketch of a tetrasporic plant showing the branching and the tetrasporiferous branchlets. × 3.6

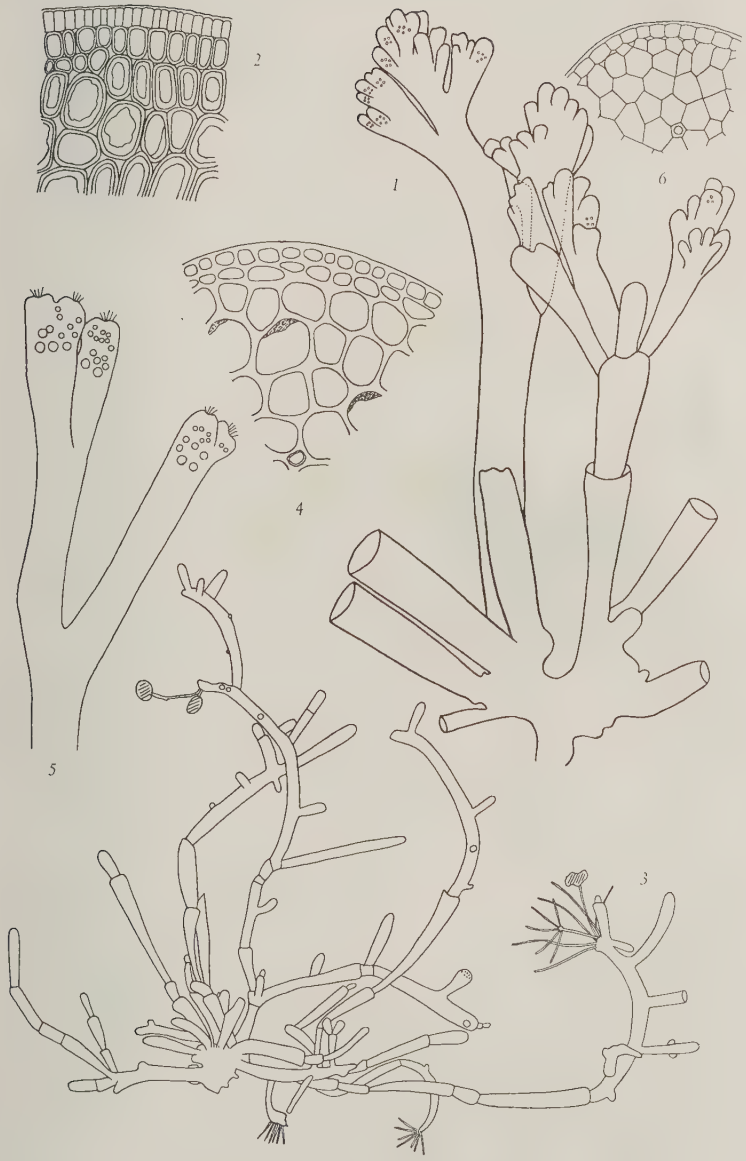
FIG. 2. *L. longicaulis*, sp. nov. Transverse section of a branchlet, showing annular thickenings on the medullary cell walls. × 97

FIG. 3. *L. articulata*, sp. nov. Habit sketch of a young plant, showing the branching, the articulations, the repent rhizoid-bearing branches, and a young tetrasporiferous branchlet. × 2.6

FIG. 4. *L. articulata*, sp. nov. Transverse section of a branchlet. × 97

FIG. 5. *L. tenera*, sp. nov. Upper part of a branch, showing the apices and the position of the tetrasporangia. × 17

FIG. 6. *L. tenera*, sp. nov. A sector of a transverse section of a branchlet. × 97



Marine algae of the genus Laurencia

EXPLANATION OF PLATE III

FIG. 1. *Laurencia chinensis*, sp. nov. Habit sketch of the basal part of a young plant, showing the stoloniferous filament and the branching. × 3

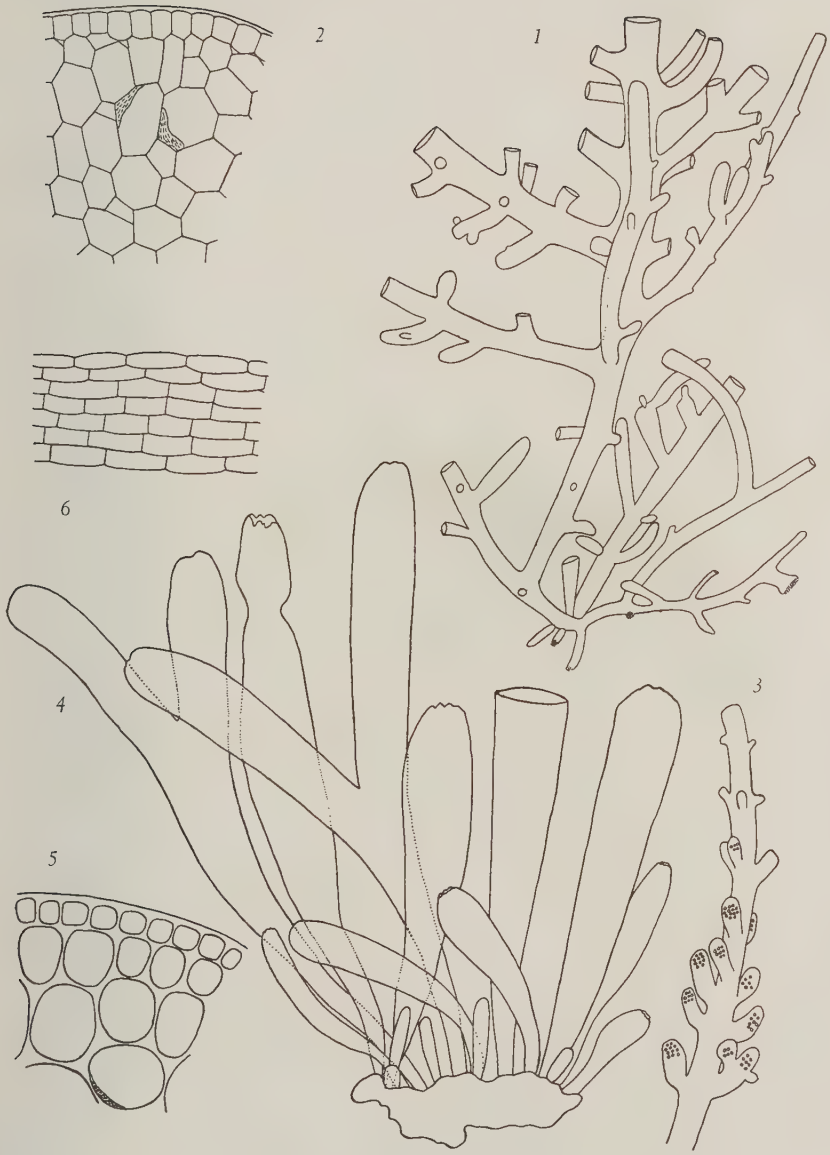
FIG. 2. *L. chinensis*, sp. nov. Transverse section of a branchlet. × 114

FIG. 3. *L. chinensis*, sp. nov. Upper part of a tetrasporiferous branch. × 4.5

FIG. 4. *L. subsimplex*, sp. nov. Habit sketch of a tuft of fronds. × 3

FIG. 5. *L. subsimplex*, sp. nov. Transverse section of a frond, near the tip. × 114

FIG. 6. *L. subsimplex*, sp. nov. Surface view of some epidermal cells near the tip of a frond. × 114



Marine algae of the genus Laurencia

EXPLANATION OF PLATE IV

Laurencia parvipapillata, sp. nov.

FIG. 1. Habit sketch of a part of a tetrasporic plant, showing the branching and two young tetrasporiferous branchlets. × 3

FIG. 2. Parts of two branches, showing cohesion by rhizoidal tenacula. × 4.5

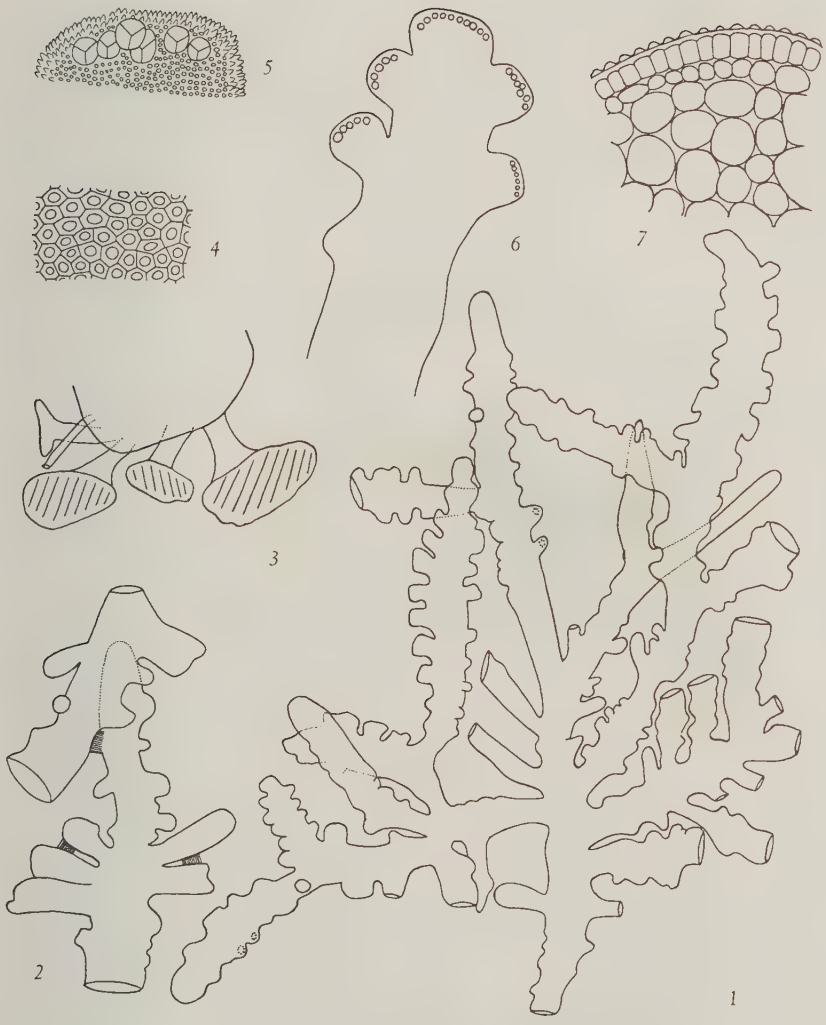
FIG. 3. Basal part of a frond, showing some rhizoids. × 25

FIG. 4. Surface view of some epidermal cells near the tip of a branchlet. × 114

FIG. 5. Surface view of the fertile tip of a branchlet, showing the mammilliform projection of the epidermal cells and some tetrasporangia. × 47

FIG. 6. Upper part of a tetrasporiferous branch, showing the margin of the fertile branchlets with their sporangia. × 12

FIG. 7. Transverse section of a branchlet, showing the papillate epidermal cells. × 114



Marine algae of the genus Laurencia

SEED DEVELOPMENT IN THE MORNING-GLORY (*IPOMOEA RUBRO-CAERULEA* HOOK.)

EDWARD F. WOODCOCK

A STUDY of the literature on the genus Ipomoea gives very little information concerning the morphology of the seed of *I. rubro-caerulea* Hook. Lubbock (2) describes the mature seed, but includes nothing about its early development. The vegetative structure and culture of the sweet potato (*Ipomoea Batatus* Poir.), a related species, has received much attention because of its economic importance (Hayward, 1). A comprehensive survey of the published records on seed production in the sweet potato has been made by Stout (3). The lack of data on the stages of its seed development is explained by the fact that even in regions where the plant grows and flowers abundantly only a few seeds are produced.

Since *I. rubro-caerulea* Hook. is quite similar to *I. Batatus* Poir. in flower structure and also since it produces seed quite abundantly, this study of the complete seed development may be of assistance in explaining the sterility existing in the sweet potato.

DESCRIPTION AND DISCUSSION OF THE MORPHOLOGY OF THE SEED

The stages of seed development were studied by means of microtome sections cut twelve microns thick and stained with Delafield's haematoxylin.

The two-loculed ovary has two anatropous ovules in each locule. The ovules are more or less basal and develop from an axile placenta at the inner angle of each locule. Each ovule (Pl. I, Fig. 1; Pl. II, Fig. 1) is elongated and in cross section is triangular (Pl. I, Fig. 2; Pl. II, Fig. 2). It has a short funiculus, which is curved and much constricted at the point of union with the chalazal region.

The ovule is not differentiated into a distinct integument and nucellus region, as is generally true of ovules. The long micropyle

is formed by an invagination of the ovule near the chalazal region. The epidermis (Pl. II, Fig. 6) consists of flattened cells, each of which has an outer wall that varies in convexity. Sometimes this outer wall is extended to form a short one-celled blunt hair. Underneath the epidermis are two narrower layers of cells, the inner one undergoing marked changes as the mature seed coat is formed. Vascular tissue enters the ovule from the funiculus and passes through the dorsal region of the ovule to the base of the embryo sac. From this point it proceeds through the ventral region between the embryo sac and the surface of the ovule almost to the micropylar region (Pl. II, Fig. 1).

At the time the embryo begins to enlarge it is furnished with a broad many-celled spindle-shaped suspensor (Pl. II, Fig. 9). The embryo sac is lined with cytoplasm and endosperm nuclei. By the time the embryo has produced well-marked cotyledons (Pl. I, Fig. 3) the endosperm is cellular in the micropylar region of the embryo sac, and the sac is crescent-shaped when observed in cross section. The convex side of the sac is toward the dorsal side of the ovule, and the edges of the sac partly enclose a ventral ridge that extends the length of the ovule. This ridge consists of vascular tissue surrounded by parenchyma. As development of the embryo continues the two cotyledons become thin and extend the length of the embryo sac. Each cotyledon is deeply bifid at the apex and cordate at the base. A cross section of the ovule at this stage just above the notch in the cotyledons (Pl. I, Fig. 6; Pl. III, Fig. 10) shows the shape of the embryo sac, and the folding of the cotyledons about the ventral ridge inside the ovule. At the pointed basal end of the ovule this ridge is divided, which causes the embryo sac to be divided into a central lobe and two lateral ones. In a cross section through the ovule just below the base of the cotyledons (Pl. I, Fig. 7; Pl. III, Fig. 11) the basal lobes of the cotyledon are evident in the lateral lobes of the embryo sac. The central lobe of the sac contains the plumule, which is partly surrounded by the stalks of the cotyledons. At this stage of development the region about the embryo in the embryo sac is filled with a cellular endosperm, the cells of which are large and thin-walled and contain only a few starch grains.

As the further development of the seed occurs the area of the cotyledons increases very much, and as a result of their close confinement inside the seed coat they become much folded transversely

and to some extent longitudinally (Pl. I, Figs. 4–5; Pl. II, Figs. 7–8). The radicle and hypocotyl also are pushed into the narrow pointed end of the seed. The plumule appears as a lobed elevation at the base of the cotyledons. The embryo is surrounded by a cellular endosperm, in which only a few starch grains are visible.

There occurs a further folding of the cotyledons of the embryo as the seed matures. In the mature stage (Pl. I, Fig. 8; Pl. III, Fig. 14) the much-folded cotyledons are evident as they are wrapped about the ventral ridge. The cellular endosperm extends into the folds of the cotyledons, and its cells have only a few starch grains. Since some storage tissue is in the form of endosperm, the mature seed may be considered an albuminous type. The large embryo contains an abundance of stored food. The seed coat (Pl. III, Fig. 13) consists largely of the modified second layer of cells under the epidermis. These cells have increased markedly in their radial dimension, appearing as narrow cells perpendicular to the surface of the seed. Their walls are rather thin, but they are suberized, so that the layer of cells serves as a very efficient protection against loss of water from the mature seed. Figure 9 of Plate I and Figure 12 of Plate III show the cross section of the folded cotyledons of a mature embryo. Figure 3 of Plate II illustrates the two cotyledons of a young seedling after the folds had been pressed out of them. Each cotyledon has a deep apical notch and two basal lobes. Figures 4 and 5 of Plate II show the ventral and dorsal views respectively of a complete embryo removed from the seed coat. The folding of the cotyledons is more evident in these sketches than in sectional views.

SUMMARY

The ovule of *Ipomoea rubro-caerulea* Hook. is anatropous, elongated, and triangular when observed in cross section. There is no distinct integument in the ovule. The micropyle is formed by an invagination of the end of the ovule next to the funiculus. As the seed matures the cotyledons of the embryo become much folded and wrap about a ventral ridge of tissue, which extends inward from the seed coat. The mature embryo is surrounded by a cellular endosperm, in which there is a scarcity of starch grains.

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EXPLANATION OF PLATE I

Stages in development of seed of *Ipomoea rubro-caerulea* Hook.

Fig. 1. Longitudinal section of ovule. × 8

Fig. 2. Cross section of ovule, with embryo sac and endosperm nuclei. × 10

Fig. 3. Longitudinal section of ovule, with embryo and suspensor. Cellular endosperm evident in micropylar region of embryo sac. × 8

Fig. 4. Median longitudinal section of young seed. Radicle, hypocotyl, and plumule well developed. Cotyledons folded. Embryo surrounded by cellular endosperm. × 7

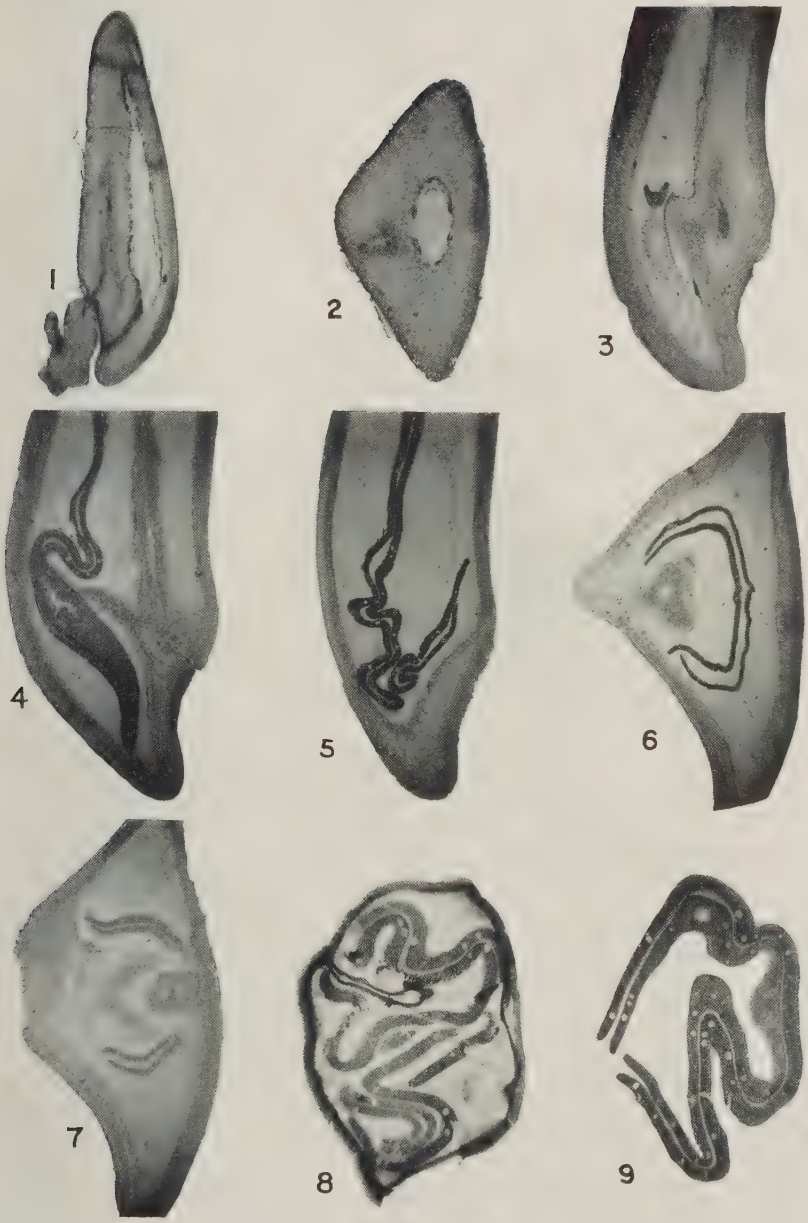
Fig. 5. Longitudinal section cut to one side of median section. Extensive folding of the cotyledons evident. × 7

Fig. 6. Cross section of partly mature seed. Cotyledons folded about ventral ridge, which projects into the embryo sac. × 7

Fig. 7. Cross section of partly mature seed through the micropylar end. Basal lobes of cotyledon, stalks of cotyledons, and plumule are evident. × 9

Fig. 8. Cross section of mature seed. × 9

Fig. 9. Cross section of cotyledons of mature embryo. × 7



Seed development in *Ipomoea rubro-caerulea* Hook.

NOTE

Seed of *Ipomoea rubro-caerulea* Hook.

All figures drawn with the aid of a camera lucida or a binocular microscope. The following abbreviations are used: C, cotyledons; CL, basal lobe of cotyledon; CS, seed coat; E, embryo; EN, endosperm; EP, epidermis; ES, embryo sac; F, funiculus; H, hypocotyl; M, micropyle; P, plumule; R, radicle; S, suspensor; SC, layer of cells which later become elongated to form the major part of seed coat; SCL, elongated, suberized cells of seed coat; ST, stalks of cotyledons; V, vascular tissue; VR, ventral ridge

EXPLANATION OF PLATE II

Fig. 1. Longitudinal section of young ovule, with endosperm in free nuclear condition. Embryo with large many-celled suspensor. Micropyle formed by invagination of ovule. × 16

Fig. 2. Cross section of young ovule and suspensor. × 16

Fig. 3. Outline of cotyledons. Each has a deep apical notch, two long apical lobes, and two short basal lobes. × 1

Fig. 4. Sketch of ventral side of embryo, which has been removed from seed coat

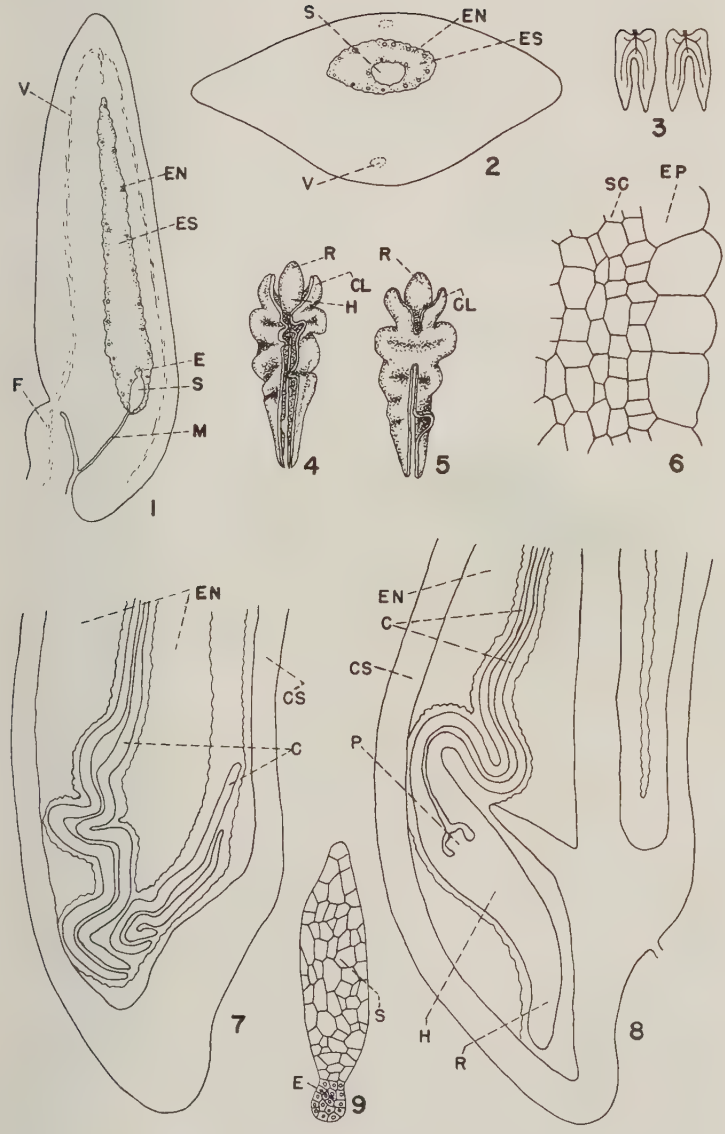
Fig. 5. Sketch of dorsal side of embryo, which has been removed from seed coat

Fig. 6. Cross section of outer region of ovule. Epidermis and underlying layers evident. × 430

Fig. 7. Longitudinal section of partly mature seed, the section passing to one side of the median region. Cotyledons much folded. × 16

Fig. 8. Median longitudinal section of partly mature seed. Embryo surrounded by cellular endosperm. Plumule well developed at base of the folded cotyledons. × 16

Fig. 9. Longitudinal section of embryo and suspensor. × 207



Seed development in *Ipomoea rubro-caerulea* Hook.

EXPLANATION OF PLATE III

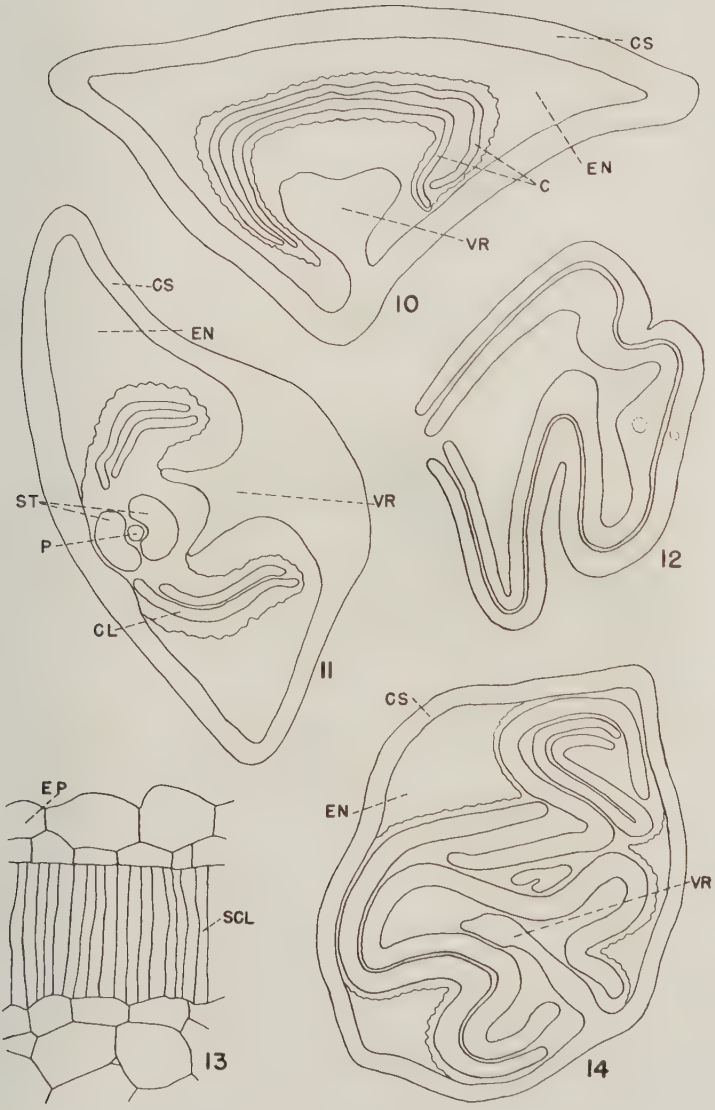
FIG. 10. Cross section of partly mature seed. Thin cotyledons wrapped about the ventral ridge, which extends inward from the seed coat. Cotyledons surrounded by cellular endosperm. × 16

FIG. 11. Cross section of partly mature seed through apical region. Basal lobes of cotyledons evident. × 16

FIG. 12. Cross section of cotyledons of embryo, which has been removed from seed coat. × 16

FIG. 13. Cross section of mature seed coat. Second layer underneath epidermis consists of much-elongated suberized cells. × 430

FIG. 14. Cross section of mature seed. Cellular endosperm next to seed coat in folds of embryo. Ventral ridge evident. × 16



Seed development in *Ipomoea rubro-caerulea* Hook.

FORESTRY

SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES. XIV *

DOW V. BAXTER

A LARGE number of resupinate polypores of northern Europe and Asia are indigenous to the region of the Great Lakes. Furthermore, the majority of porias which occur in Michigan, Minnesota, and Wisconsin can be found throughout the United States. There are, however, certain variants and forms of these fungi in different localities; some are correlated with the occurrence of different types of substrata, and others exhibit macroscopic variations due to moisture conditions.

Races or strains likewise occur, and can be separated from each other largely on the basis of their growth reactions in culture. *Poria laevigata* is one of many examples that might be cited. The race of this species on hickory differs from that on birch in culture (3). See Table I for its characteristics in culture.

It is evident that study of the resupinate polypores involves work in the field, not only within the limits of the state boundaries in the region of the Great Lakes, but in other areas as well. Resupinate plants from two continents have been observed in nature and in the laboratory, and numerous collections from Asia, particularly Siberia, have been compared with ones in Leningrad and western Alaska.

* Throughout the work on these monographs I am indebted to many individuals and institutions for suggestions, help, and privileges extended to me. My appreciation is expressed particularly to the men who have accompanied me on my ten expeditions to Alaska, the Yukon Territory, and the Northwest Territories. Much credit is due them for aiding in the collection and care of specimens and for living, at times, under rather difficult circumstances. I am under obligation to Professors T. G. Halle and Gunnar Samuelson, of Naturhistoriska Riksmuséet in Stockholm, with whom I have had the pleasure of association. Thanks are due several American institutions and scholars also. To the authorities at the New York Botanical Garden, to Dr. W. H. Long, Albuquerque, New Mexico, to the staff of the Division of Pathological and Mycological Collections of the United States Department of Agriculture, and to Professor H. H. Bartlett, of the University of Michigan, I am especially indebted.

TABLE I

GROWTH CHARACTERISTICS OF CERTAIN RESUPINATE POLYPORES ON MALT AGAR

NAME	IN LIGHT						IN DARK				
	Rate in mm. 2 weeks	Color (Ridgway)	Texture and form	Character of margin	Agar discoloration	Pore formation	Rate in mm. 2 weeks	Color (Ridgway)	Texture and form	Agar discoloration	Pore formation
Poria crustulina on white spruce from Alaska	8.8	White	Cottony to slightly silky	Indefinite	None	None	13.2	White	Cottony, concentric-ring growth	None	None
Fomes robustus on *Betula nigra* from Great Falls, Virginia	...	Olive ochre or yellow ochre to cinnamon buff	Silky to chamois, concentric	Definite	None	None	...	Chamois to antimony yellow to cinnamon brown	Silky to chamois	None	None
Poria laevigata on *Betula nigra* from Great Falls, Virginia	...	Pinkish buff to buckthorn brown	Cottony	Indefinite	Dark red at margins	None	...	Buckthorn brown	Cottony	Very slight	None
Poria corticola on aspen from Mud Lake, Michigan	26.5	White	Granular	Indefinite	None	On inoculum	26.8	White	Granular to chamois	None	Slight on inoculum

Paper XIV discusses twelve species of resupinate polypores and includes the description of one new plant.

Polyporus pallescens Karst., *p. p.* (non Fries), ex Romell, Hymen. Lap., p. 19. 1911

(Plate I)

Polyporus vitreus Pers. *sensu* Karsten. Herb. Bresadola, Stockholm.

Important specimens:

Polyporus pallescens Karst. on Betula, Björkliden. Herb. Mycolog. Lars Romell, Stockholm. Hymen. Lap. 1910.

Polyporus pallescens Karst. on *Pinus silvestris*, Kalixfors. Herb. Mycolog. Lars Romell, Stockholm. Hymen. Lap. 1910.

Polyporus pallescens Karst. on Betula, Torneträsk. Herb. Mycolog. Lars Romell, Stockholm. Hymen. Lap. 1910.

Physisporinus vitreus Pers., *sensu* P. A. Karsten *p. p.*, on Betula, Mustiala. Herb. Bresadola, Stockholm.

Fructification annual, resupinate, effused up to 9 cm., often cracking, as in *Poria subacida*, upon drying, or effused-reflexed, the pileus in such specimens $20 \times 10 \times 3$ mm., drying thin and Stereum-like, pubescent to almost glabrous, "cartridge buff," with "army-brown" margin; margin incurved, paper-thin, less than 0.3 mm. thick, brittle; resupinate plants up to 3 mm., usually about 1.5–2 mm., thick; margin pubescent, wavy or opening in fan-shaped extensions of the fungus, mostly adpressed to the substratum and Stereum-like, 0.5–10 mm. wide, "ivory yellow," "light buff," or "seashell pink," mostly remaining sterile, but occasionally becoming fertile; subiculum thin, less than 0.3 mm. wide, "light buff"; tubes 0.5–2.5 mm., mostly 1 mm., long; mouths white, drying to "ivory yellow," "warm buff," and occasionally to "snuff brown," 4–6 to a mm.; dissepiments thin; spores 2-guttulate, $3–4 \times 1.5–2$ μ; hyphae soft, not fibular, hymenial hyphae 2–3 μ in diameter, hyphae of the subiculum 3–4 μ in diameter, hyphal pegs present, often encrusted and resembling cystidia.

Allied species. — *Polyporus pallescens* is distinguished from *Pol. euporus* by its lack of cystidia and by the smaller pores. Nor are the tubes and mouths pink or reddish in *Pol. pallescens*. Published discussions of this species and *Poria byssina* point to similarities with reference to color and even to microscopic features. *Pol. pallescens* is more watery when fresh, dries hard, and

frequently curls up at the edges. Its Stereum-like border is distinctive. Dried specimens may suggest *P. undata* (Pers.) Bres., but the conspicuous Stereum-like margin in *Pol. pallescens* again serves to separate the two plants.

Bourdot and Galzin (2) call attention to the resemblance of the plant to *Coriolus Genistae* Bourd. and Galz., but they point out minute differences in the hyphal characters of the two plants. All the hyphae of *C. Genistae* are said to be of similar size. I have not seen this species.

Romell (4) states that *Polyporus pallescens* is the plant that Karsten found at Mustiala, in Finland, on the hymenium of *Fomes fomentarius*. Karsten's other collections belong to *Pol. velutinus*. This plant is not *Pol. pallescens* of Fries, which seems to be identical with *Pol. fumosus, holmiensis, salignus*, and *scanicus*, so far as authentic specimens in the Kew Herbarium are concerned.

The incurved paper-thin pileus-like margins of some specimens may suggest *Polyporus floriformis*. The imbricate pilei of that species will readily serve as a distinguishing feature.

Habitat. — *Betula nigra, Nyssa sylvatica, Picea glauca, Pinus contorta, Prunus cerasus.*

Distribution. — Alberta, Yukon Territory, North Dakota, West Virginia.

Poria mutans Pk., Forty-third Rep. New York State Mus., p. 30. 1890

Type:

Poria mutans Pk. on decaying wood of deciduous trees, Selkirk, New York. Coll. C. H. Peck, Aug. New York State Herb., Albany, N. Y.

Fructification often effused for 30 cm. or more, annual, drying hard and firm; margin abrupt, sterile when young, becoming entirely fertile; subiculum mostly less than 1 mm. thick; tubes up to 6.5 mm. long, mostly about 4 mm., yellow when fresh, drying "ecru drab" to "dark vinaceous brown"; mouths 3–6, mostly 4, to a mm., drying from yellow to "light pinkish cinnamon" or "dark vinaceous drab"; spores ellipsoidal or nearly globose, hyaline, 3–5 × 2.5–4 μ; no cystidia; hyphae often encrusted, seldom branched, 2.5–4 μ in diameter; clamp connections present.

Allied species. — *Poria mutans* is allied to *P. spissa* (Schw.) Cooke. Both plants change from yellow or orange to red upon drying. *P. mutans* is harder and frequently cracks up into segments upon drying. Its spores are globose or nearly so and measure 3–5 × 2.5–4 μ, whereas those of *P. spissa* are 4–5 × 1 μ.

Polyporus croceus Pers. ex Fries occurs commonly on chestnut, as does *Poria mutans*. *Pol. croceus*, furthermore, is also buff or orange when fresh and becomes reddish brown upon drying. In addition, the spores of these two fungi are similar. The tubes of *Pol. croceus* are, however, much longer on the average than those of *P. mutans*, ranging from about 5 to 20 mm. *Pol. croceus* is usually pileate.

Habitat. — *Castanea dentata, Juglans cinerea, Quercus sp.*

Distribution. — Ontario, Alabama, California, Connecticut, District of Columbia, Kentucky, Maryland, Michigan, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Virginia, West Virginia.

Occurrence. — *Poria mutans* is commonly distributed throughout the range of chestnut, often fruiting on the ends of old logs and in hollow butts of this tree. It is one of the few fungi of the genus that occur on charred logs and decay burned slash.

Decay. — *Poria mutans* is associated with a pocket rot. Frequently the decay is so far advanced when fruiting plants are found that the logs attacked consist of only concentric layers of reddish-brown rotten wood loosely held together. The type of decay associated with it is, therefore, similar to that produced by *Polyporus croceus*.

Poria mutans tenuis Pk., Forty-third Rep. New York State Mus., p. 39. 1890

Type:

Poria mutans tenuis Peck on wood and bark of spruce, Sevey, New York. Coll. C. H. Peck, July. New York State Herb., Albany, N. Y.

Fructification annual, separable, effused for 12 cm. or more, thin; margin sterile, 1 cm. or more wide, "vinaceous cinnamon"; subiculum less than 0.3 mm. thick; tubes less than 0.5 mm. long; mouths yellowish when fresh (Peck), drying "pinkish cinnamon" or "onion-skin pink" to "burnt umber," 3–4, mostly 3, to a mm.; basidia 12–18 × 3–6 μ; spores cylindric or allantoid, 4–5 (6)

$\times$ 1–2 μ; no cystidia; hyphae of subiculum thin-walled, sometimes branched, often encrusted, 2–4 μ in diameter; clamp connections present.

Allied species. — This plant is characterized by its thinness and by the "onion-skin-pink" color. It differs from *Poria mutans* not only in its color when dried but also in the fact that it is not hard and bony in herbarium specimens. The microscopic features are generally similar, although the spores are more nearly globose in *P. mutans* and cylindrical or allantoid in *P. mutans tenuis*.

It is, however, difficult to distinguish *Poria mutans tenuis* from *P. purpurea*. The combination of characters such as the "onion-skin-pink" color when dry and the generally shorter spores of *P. mutans tenuis* serve to separate the two plants. The spore character alone, like the color feature by itself, however, is not always reliable. Measurements of the spores of the two plants may be similar, but in most specimens the spores of *P. purpurea* are 5–8 (6–7 $\times$ 2) 2–2.5 μ, whereas those of *P. mutans tenuis* are 4–5 (6) $\times$ 1–2 μ.

Habitat. — *Aesculus californica.*

Distribution. — California, New York, Virginia.

Polyporus nidulans Fr., Syst. Myc., 1 : 362. 1821

Boletus rutilans Pers., Ic. Descr. Fung., p. 18. 1798.
Pol. rutilans Fr., Syst. Myc., 1 : 363. 1821.
Hapalopilus nidulans Karst., Rev. Myc., 3 : 18. 1881.
Inonotus nidulans Karst., Fin. Basidv., p. 332. 1889.
Hapalopilus rutilans (Pers.) Murr., Bull. Torr. Bot. Club, 31 : 416. 1904.

Fructification annual, spongy and watery when fresh, friable when dry, effused, reflexed, 1.5–5 $\times$ 2–8 $\times$ 0.5–2 μ, or occasionally resupinate; surface reddish or cinnamon to yellowish brown, "pecan brown" to "cinnamon buff," velvety or fibrillose to glabrous, azonate; margin purplish or red where bruised; context concolorous with pileus, turning purplish then colorless with KOH, 2–10 mm. thick; tubes concolorous, 1–7 mm. long; mouths grayish to brown, 2–4, mostly 2–3, to a mm.; basidia 4–5 μ in diameter; spores hyaline, smooth, globose, or ovoid, 2.5 $\times$ 3 μ; no setae; hyphae somewhat branched, thick-walled, 4–6 μ in diameter.

Allied species. — *Polyporus nidulans* is separated from *Pol. radiatus*

by the fact that setae, although rare in *Pol. radiatus*, do not occur at all in *Pol. nidulans*.

Habitat. — *Acer saccharum, Alnus sp., Betula lenta, B. occidentalis, Carya sp., Castanea dentata, Populus tremuloides, Quercus coccinea, Vitus sp.*

Distribution. — Ontario, Idaho, Illinois, Indiana, Iowa, Kansas, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New Mexico, New York, Ohio, Pennsylvania, South Dakota, Tennessee, Virginia, Wisconsin.

Occurrence. — *Polyporus nidulans* is common on hickory and oak.

Polyporus radiatus Sowerby ex Fr., Syst. Myc., 1 : 369. 1821

Boletus radiatus Sow., Eng. Fungi, pl. 196. 1799.
Inonotus radiatus (Sow.) Karst., Rev. Myc., 3 : 19. 1881.

Fructification mostly sessile, imbricate, 2–5 × 2–8 × 0.3–1.5 cm., but semiresupinate at times, yellow brown to rusty brown, "honey yellow" to "antique brown," upper surface velvety to glabrous, usually zonate; context "Sayal brown" or concolorous with pileus, corky, zonate, 2–12 mm. thick; tubes 1–8 mm. long (Overh.); mouths grayish brown, "light buff" to rusty brown, "antique brown," mostly 4–5 to a mm.; basidia 5–6.5 μ in diameter; spores hyaline, smooth, ellipsoid, 4–5 × 3–4 μ; setae rare, projecting 5–10 μ; hyphae rarely branched, 4–8 μ in diameter.

Allied species. — *Polyporus radiatus* is allied to *Pol. cuticularis*, which, however, bears abundant spores and setae. Furthermore, the spores of *Pol. cuticularis* are somewhat longer (5.5–7.5 μ) than those of *Pol. radiatus*. In macroscopic appearance *Pol. radiatus* most closely resembles *Pol. nidulans*, but differs in that setae are not found in *Pol. nidulans*. Birch and alder are common substrata for *Pol. radiatus*, whereas *Pol. nidulans* occurs more widely.

Cultures. — Isolated from *Betula kenaica*, Moose Pass, Alaska. *Polyporus radiatus* belongs to the average-temperature class. The temperature range is small, and the plant grows best in the dark.

One-year-old cultures of the fungus are readily distinguished

from the majority of the members of this group by the yellowish green ("primuline-yellow") mycelium. *Polyporus radiatus* is the only fungus in a lot of 147 species and races that turns the agar olive green in one-month-old cultures.

Wood-block cultures illustrate well the fact that this species seldom occurs on conifers. Red-gum blocks become covered with the mycelium and soon form nodulose growths that resemble abortive fruiting bodies. White-pine blocks in separate cultures or in the same flasks with red gum do not become enveloped by the mycelium.

Habitat. — *Abies Fraseri, Acer rubrum, A. saccharum, Alnus incana, A. sinuata, Betula kenaica, B. lutea, Fagus grandifolia, Juglans nigra, Populus trichocarpa, Quercus Catesbaei, Q. stellata.*

Distribution. — Nova Scotia, Alaska, Connecticut, Florida, Illinois, Massachusetts, Michigan, New Hampshire, New Jersey, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, Tennessee.

Occurrence. — This fungus occurs most commonly on birch and alder. Next to *Fomes igniarius nigricans*, it is the most common polypore on these trees in Alaska.

Poria vulgaris Fr. *sensu* Romell, Svensk Botanisk Tidskrift, 20, No. 20. 1926. Not Arkiv für Botanik, 11, No. 25. 1911

(Plates II–IV)

Polyporus biguttulata. Herb. Mycolog. Lars Romell, Stockholm.
Poria calcea (Fr.) Bres. var. *fragilis* Bourdot & Galzin, Hymen. de France. 1927.

Important specimens:

Poria biguttulata. Bromma, 1913. Det. Romell. Herb. Mycolog. Lars Romell 12935, Stockholm.
Polyporus vulgaris, sensu stricto. Saltsjö-Durnäs, 1915. Herb. Mycolog. Lars Romell 12942, Stockholm.

Fructification annual, whitish, somewhat soft, effused in patches extending 10 cm. in length, mostly 1 mm., but up to about 3.5 mm., thick; margin white, 1–2 mm. wide, fimbriate, neither distinctly cottony nor rhizomorphic, becoming fertile; subiculum white, less than 0.5 mm. wide; tubes 1–3.5 mm., mostly 1–1.5 mm., long; mouths white to "cartridge buff," "ivory yellow," sometimes "pale pinkish buff," but those newly formed remaining

concolorous with the white margin and thus producing a distinctly white or light-colored border often 4 mm. or more wide around the plant, somewhat glistening, 4–6, mostly 4–5, to a mm., angular; dissepiments minutely fringed; basidia 7–14 × 4–4.5 (6) μ; spores 2-guttulate, allantoid, not strongly curved, 4–6 × 1–1.5 (2) μ; hyphae occasionally septate, often encrusted.

Allied species. — The interpretation of this species is that of Romell, and is the one held by contemporary workers in Sweden. *Poria vulgaris* is allied to *P. lenis* and *P. xantha*. The chief distinction between it and *P. lenis* is in the spore character. In the latter species the spores are strongly curved so as to form almost a half circle, whereas in *P. vulgaris* they are not strongly curved. During wet seasons or in extremely wet environments *P. vulgaris* may exhibit a soft cottony margin, which may thus appear macroscopically somewhat like that of *P. lenis*. The spore character is a reliable one to distinguish the two plants. Ordinarily, however, the margin described for *P. vulgaris* can be used as a supplementary means of separating them. *P. lenis* is distinctly soft to the touch, usually exhibiting a conspicuously cottony margin and also a fluffy mycelium, which appears in the badly decayed wood in the immediate vicinity of the fruiting structure. It is to be reëmphasized that the typical margin of *P. vulgaris* is fimbriate, more or less adpressed to the substratum, and not generally cottony in nature.

The spores may be used to separate *Poria xantha* from *P. vulgaris*, for in freshly collected *P. vulgaris* they are 2-guttulate, whereas in *P. xantha* they do not exhibit droplets. The sulphurous color of the tubes of *P. xantha* may serve as a supplementary means of distinction between the two species in typical collections.

Poria vulgaris and *Polyporus subfuscoflavidus* may readily be confused, but can be separated by the spore character, supplemented by color features and habit of growth.

In *Poria vulgaris* the spores are narrow, 4–6 × 1–1.5 (2) μ, and usually 1 μ in diameter. Rarely does one find a spore 2 μ in width. Those of *Polyporus subfuscoflavidus* are 4.5–7 × 1.5–2.5 μ. Spores as small as 1.5 μ in diameter are not usual. Bresadola gives a diameter of 2–2.5 μ for his specimens (*P. cinerascens*).

Poria vulgaris is a more fragile plant than *Polyporus subfuscoflavidus*, being by no means so thick and coarse. *Pol. subfuscoflavidus* lacks the thin, almost transparent, margin illustrated in typical specimens of *P. vulgaris*. The ashy color of dried specimens of *Pol. subfuscoflavidus* is helpful in making determinations of herbarium material, but is less useful for diagnosing fresh collections in the field. In mature growing Swedish collections of *P. vulgaris* the mouths are "cartridge buff." In the young stages fresh specimens exhibit a faint blue, something like that of *Pol. caesius*, but this color disappears as the plant ages. In dried collections the tubes and mouths may remain "cartridge buff" or turn darker, to "cream buff," but the marginal areas usually retain their lighter or whitish appearance. This feature is an important one to consider in making determinations.

The name "*vulgaris*" has been confused in herbaria with "*vaporaria*," partly because a number of different plants are to be found under these names at various institutions. The spores of the two species are similar, but in *Poria vaporaria* the mouths of the tubes are mostly 1–2 to a mm., whereas in *P. vulgaris* they are generally 4–5 to a mm. Moreover, the mouths of *P. vaporaria* do not glisten (see Pl. V).

When *Poria vulgaris* is found growing in extremely wet spots, or when the fruiting bodies have been water-soaked in the field by constant rains, the fungus differs considerably in its macroscopic features from the typical growth forms. In this condition and, except for the pore character, in habit of growth and color, one is reminded of *Corticium lividum*.

Many different growth forms of *Polyporus vulgaris* have received "herbarium" names at European institutions. See Plate II.

Habitat. — *Abies balsamea, A. concolor, Lithocarpus densiflora, Picea Engelmannii, P. glauca, P. Mariana, P. rubra, P. sitchensis, Pinus sp., Pinus Banksiana, P. clausa, P. contorta, P. Strobus, Pseudotsuga taxifolia, Thuja occidentalis.*

Distribution. — Alberta, Northwest Territories, Nova Scotia, Ontario, Quebec, Alaska, California, Florida, Idaho, Massachusetts, Michigan, Minnesota, Montana, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oregon, Utah, Wisconsin.

Occurrence. — *Poria vulgaris* is one of the most common members of the resupinate polypores in Sweden, and it occurs much more abundantly in northern Europe than in America. In Sweden it is usual to find this plant on old fence rails, but in this country the poria seldom attacks structural timbers.

Polyporus dichrous Fries, Hym. eur., p. 550. 1821

Gloeoporus conchoides Mont. American herbaria.
Gloeoporus dichrous (Fr.) Bres., Hedw., 53 : 74. 1914.
Leptoporus dichrous (Fr.) Quél., Fl. Myc. de France, p. 388. 1888.

Fructification annual, sessile, effused-reflexed, 0.5–3 × 1–5 × 0.1–0.5 cm., or sometimes resupinate; surface of pileus white or whitish, velvety to glabrous; margin thin, sterile below; context white, 1–4 mm. thick; tubes flesh-colored or purplish, "fawn color" to "olive brown," less than 1 mm. long, waxy and separable from the context in a thin waxy or gelatinous layer when fresh or moistened; mouths concolorous with the tubes, 5–7 to a mm.; basidia 12–17 × 3–4 μ; spores hyaline, smooth, allantoid, 3.5–4.5 × 0.5–1.5 μ; no cystidia; hyphae thick-walled, somewhat branched, 3.5–4.5 μ in diameter.

Allied species. — There are no plants closely allied to this fungus excepting *Poria taxicola*, which may prove to be the resupinate form of *Polyporus dichrous*. The waxy consistency of the plants, the color of the mouths (flesh to reddish purple), and the spores are similar in the two fungi. Both are found on hardwoods and conifers, but ordinarily *Pol. dichrous* occurs on hardwoods, whereas *P. taxicola* appears on conifers.

Habitat. — *Acer rubrum, A. saccharum, Betula lutea, B. neoalaskana, Cephalanthus sp., Cornus florida, Fagus grandifolia, Fraxinus sp., Hicoria cordiformis, Juniperus virginiana, Larix occidentalis, Liquidambar styraciflua, Liriodendron tulipifera, Melia azedarach, Nyssa biflora, Picea rubra, Pinus caribaea, P. monticola, P. ponderosa, P. Strobus, P. taeda, P. virginiana, Populus balsamifera, P. tremuloides, Pseudotsuga taxifolia, Quercus agrifolia, Q. alba, Q. Garryana, Q. palustris, Q. velutina, Q. virginiana, Rhus vernix, Salix sp., Syringa vulgaris, Taxodium distichum, Thuja occidentalis, T. plicata, Tsuga heterophylla, Ulmus americana.*

Distribution. — British Columbia, Manitoba, Northwest Territories, Ontario, Alaska, Alabama, Arkansas, California, Colorado, Con-

necticut, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Rhode Island, South Dakota, Tennessee, Texas, Virginia, Washington, West Virginia, Wisconsin.

Occurrence. — The fungus usually grows on slash, although occasionally it appears on wood products. It is known, for example, to decay, in storage, turpentine barrels made of slash pine.

Trametes hispida Pass., Nuov. Giorn. Bot. Ital., 4 : 155. 1872

Polyporus Lindheimeri Berk. & Curt., Grevillea, 1 : 50. 1872.
Irpex grossus Kalchbr., in Berk. & Curt., Grevillea, 10 : 57. 1881.
Trametes Peckii Kalchbr., Bot. Gaz., 6 : 274. 1881.
Polystictus scuirinus Kalchbr., in Thüm., Pilz. Fl. Sib., V, 14 : 897. 1882.
Polystictus Fergussoni Cooke, Grevillea, 15 : 23. 1886.
Polystictus Celottianus Sacc. & Manc., in Sacc., Syll. Fungorum, 6 : 249. 1888.
Funalia stuppea (Berk.) Murr., Bull. Torr. Bot. Club, 32 : 356. 1905.

Fructification sessile, effused-reflexed, occasionally subresupinate, imbricate, 2–10 × 2–25 × 0.5–5 cm. (Shope), corky; surface coarsely hirsute or strigose for 1–4 mm., "Sanford's brown" to bay, fading to "cinnamon buff," mostly azonate; margin acute to obtuse, fertile below; context light brown, 0.2–1 cm. thick; tubes concolorous with the context, up to 3 cm. long (Shope), becoming white-stuffed in older parts; mouths angular, averaging approximately 1 to a mm., "buckthorn brown"; basidia 8–10 μ in diameter, projecting up to 12 μ (Shope); spores hyaline, smooth, cylindric, 8–12 (15) × 2–4 μ; hyphae of context either brown, seldom branched, and 5–8 μ in diameter or hyaline, often branched, and 2–4 μ in diameter.

Allied species. — Fortunately *Trametes hispida* seldom grows in an entirely resupinate condition. Frequently, however, only resupinate parts of it are sent in for determination. It is necessary in this group in particular, to have material exhibiting plant margins, if confusion is to be avoided with *T. campestris* Quél. Even the spore measurements of the two species overlap, although most spores of *T. hispida* are shorter, 8–12 (15) μ, whereas those of *T. campestris* are 12–15 μ.

Habitat. — *Acer negundo, A. saccharinum, Hicoria ovata, Juglans sp., Malus pumila, Populus alba, P. deltoides, P. Fremontii, P. hetero-*

phylla, P. tremuloides, P. trichocarpa, Pyrus malus, Quercus velutina, Salix sp., Ulmus sp.

Distribution. — British Columbia, Manitoba, Nova Scotia, Ontario, Yukon Territory, Alaska, Alabama, California, Idaho, Illinois, Indiana, Iowa, Kansas, Maryland, Michigan, Minnesota, Missouri, Montana, Nebraska, New York, North Dakota, Ohio, Oklahoma, Oregon, South Dakota, Tennessee, Vermont, Wisconsin.

Polyporus resinascens Romell, Arkiv für Botanik, 11 : 20. 1911

(Plate VI)

Type:

Polyporus resinascens Romell on *Populus tremula*, Abisko. Herb. Mycolog. Lars Romell, Stockholm.

Fructification resupinate, adnate, 1–2 mm. thick, whitish, becoming mostly "cinnamon," sometimes "warm sepia"; margin 1–2 mm. wide, becoming "cinnamon buff"; tubes becoming resinous in texture, mostly "cinnamon," up to 2.5 mm. long; mouths concolorous with tubes, 2–4, mostly 2, to a mm.; basidia 15–20 × 4–5 μ; spores 4–5 (7) × 2–2.5 (3) μ; hyphae fibulate-septate, 2–3 μ in diameter.

Allied species. — *Polyporus resinascens* is allied to *Pol. sinuosa* and may be distinguished from that species by the fact that it dries like resin or horn, which *Pol. sinuosa* does not do. The spores of the two plants are similar.

Romell at first believed this species, which occurs on Salix about Stockholm, to be the true *Polyporus aneirinus* Somm. He states (4), however, that authentic specimens show that *Pol. aneirinus* Somm. is identical with *Pol. serenus* Karst. Both have broader spores, 5–6 × 3–4 μ, and are consequently distinct from *Pol. resinascens* and *Pol. aneirinus* Fr., which is identical with *Pol. corticola* Fr.

Habitat. — *Populus balsamifera, P. tremuloides.*

Distribution. — Alaska, Wyoming.

Remarks. — This plant, which occurs in Lapland as well as in central Sweden, appears from the records to be distinctly cordilleran, or at least western, in North America. It is probable that this species is much more common in North America than these

records suggest. *Polyporus resinascens* has undoubtedly been given other names in this country.

Polyporus albolutescens Romell, ex Weir, Hymen. Lap., 2 : 11. 1911

Trechispora onusta Karst., *p. p.*, Hedw., p. 147. 1890.
Poria onusta (Karst.) Bres., *p. p.*, "F. gall.," in Ann. Myc., 1903 : 41.

Important specimens:

Trechispora onusta Karst. on Salix, Mustiala. Herb. Bresadola, Stockholm.
Poria onusta (Karst.) Sacc. on birch, Vosges. Legit Galzin. Herb. Bresadola, Stockholm.
Poria albo-lutescens Romell on *Abies grandis*, Coolin, Idaho. Coll. and det. J. R. Weir, Aug. 14, 1920. Pathological and Mycological Collections, Washington, D. C.

Fructification annual, soft, effused occasionally for 24 inches or more, rhizomorphic, the strands frequently penetrating throughout the decayed wood substance, separable, 1–2 mm. thick; margin subiculose, "cartridge buff," "cream buff" to "chamois," tomentose; subiculum conspicuous, about 0.3 mm. thick, concolorous with margin; tubes mostly 2–3 mm. long; mouths "straw yellow" to "mustard yellow" to "primuline yellow" in herbarium specimens, circular to angular, fringed, 2–3, mostly 3, to a mm.; basidia hyaline, clavate, four-spored, 13–20 × 3–6 μ; spores hyaline, globose to ellipsoidal, angular, 3–5 × 2.5–4 μ, on sterigmata 3–7 μ long; hyphae with or without cross walls, clamp connections abundant, 2–4 μ in diameter; cystidia lacking or rare, 13–18 × 5.5–9 μ.

Allied species. — *Trechispora onusta* Karst. seems to contain two species, according to Romell — *Polyporus hymenocystis* B. & Br. and the species described by Romell as *Pol. albolutescens*. He states, "As Karsten refers his plant to a separate genus with echinulate spores, which occur in *P. hymenocystis* only, I think it inadvisable to apply his name *onustus* to the present species."

Because of the soft subiculum, *Polyporus albolutescens* suggests most strikingly *Poria subiculosa* Pk. *Pol. albolutescens*, however, retains a yellow color even in herbarium specimens, whereas dried plants of *P. subiculosa* are wood brown. Clamp connections are common in *Pol. albolutescens*, but none are found in *P. subiculosa*.

Habitat. — *Abies grandis*, *Liriodendron tulipifera*, *Picea rubra*, *Pi-*

nus resinosa, Populus trichocarpa, Thuja occidentalis, Tsuga canadensis.

Distribution.— Alaska, Idaho, Louisiana, Michigan, Minnesota, New York, North Carolina, Vermont, Wisconsin.

Poria subincarnata (Pk.) Murr., Mycologia, 13 : 86. 1921

Poria attenuata var. *subincarnata* Pk., Forty-eighth Rep. N. Y. State Mus., p. 118. 1896.

Fructification appearing in patches seldom more than 1 inch in diameter, not separable but often curling up at margins, free from or attached to flakes of bark in dried specimens; margin white, pubescent, 0.5–1 mm. broad; subiculum much less than 0.3 mm. thick, whitish; tubes less than 0.5 mm. long; mouths "tilleul buff" to "pale pinkish buff," angular; dissepiments thin, averaging 5–6 to a mm., entire or coalescing in oblique positions; pore surface cracking when dry; basidia 9–14 × 4 μ; spores hyaline, allantoid, 4–5.5 × 1 μ; hyphae thin-walled, seldom septate, sometimes encrusted, 2–3 μ in diameter, hyphal pegs projecting; no cystidia; no clamp connections.

Allied species.— *Poria subincarnata* is related to *P. sitchensis* Baxter. The spores of the two plants are similar. The resinous margins of *P. sitchensis* and the relatively thick growth habit of that species readily serve to separate the species. Dried plants of *P. sitchensis* do not break up into segments, as is characteristic of *P. subincarnata.*

Habitat. *Abies balsamifera, Chamaecyparis thyoides, Larix occidentalis, Picea Mariana, Pinus contorta, P. monticola, Tsuga canadensis.*

Distribution. British Columbia, Newfoundland, Nova Scotia, Idaho, Maine, Michigan, Minnesota, New Hampshire, New Jersey, New York, Oregon, Pennsylvania, South Dakota.

Trametes odorata (Wulf.) Fr., Epicr. Myc., p. 489. 1838

Boletus odoratus Wulf., in Jacq., Collect. ad Bot., 2 : 150. 1788.
Polyporus odoratus (Wulf.) Fr., Syst. Myc., 1 : 373. 1821.
Lenzites saepiaria porosa Pk., in Port. and Coult., Fl. Colo., U. S. Dept. Int. Geol. and Geog. Survey, Misc. Publ., 4 : 164. 1874.
Ochroporus odoratus (Wulf.) Schroet., Krypt. Fl. Schles., p. 488. 1889.
Gloeophyllum hirsutum (Schaeff.) Murr., *p. p.*, Journ. Myc., 9 : 94. 1903.
Trametes protracta Fr. American literature.
Trametes americana Overh., Polyporaceae Penn., Penn. State College, Tech. Bull. 316 : 15. 1935.

Important specimen:

Trametes odorata (Wulf.) Fr. on *Tsuga canadensis*, Bangor, Wisconsin. Coll. Newmann; det. Bresadola. Herb. Bresadola, Stockholm.

Fructification annual or perennial, sessile, coriaceous, rigid, 1–5 × 2–12 × 0.5–2 cm. (Shope); surface "antique brown" to "russet" to blackish, or sometimes weathering and bleaching to "light drab" to "smoke gray," zonate, at first strigose, becoming glabrous or nearly so; margin rounded, hirsute or velvety, tomentose, concolorous or lighter in resupinate specimens, narrowly sterile, or becoming fertile; context yellow or reddish brown, 0.5–3 cm. thick (Shope); tubes 0.3–7 mm. long; mouths poroid or daedaloid, irregular, averaging 1–2, mostly 2, to a mm.; basidia 4-spored, 6–8 × 25–35 μ; spores hyaline, smooth, cylindric to elongate-ellipsoid, 8–12 × 3–4 μ; no setae; hyphae smooth, unbranched, occasionally septate, brown, 2–4 μ in diameter.

Allied species. — *Trametes odorata* has been known under so many names that the problem of deciding which one to use becomes more difficult than determining the plant itself. *T. protracta* is one common name for it. The fungus has also been regarded as a poroid form of *Lenzites saepiaria*. Actually, *T. odorata* may be labyrinthiform, but it is never truly lamellate (see Shope [5]).

Weathered abortive resupinate specimens of *Trametes odorata* suggest *T. carbonaria*. *T. carbonaria* is a much thinner plant, however, and may be recognized further by its habit of interrupted growth. Its spores are slightly smaller also, but the difference is not great enough to be significant.

Cultures. — Differences between *Trametes odorata* and *Lenzites saepiaria* are clearly shown by cultures, as was emphasized by Snell (6). Both fungi have a comparatively high optimum temperature — between 30° C. and 34° C. The upper limits of growth for the two are, however, different. *L. saepiaria* is not inhibited in its growth until after 40° C. is reached, whereas *T. odorata* exhibits only slight growth at 38° C., and does not grow at all at 40° C. *L. saepiaria* develops faster at all temperatures, especially those between 28° C. and 36° C. Snell (6) remarks: "A test of growth upon a single agar at temperatures from 30° C. to 36° C. would serve to distinguish the fungi in culture."

Habitat. — *Abies grandis, Juniperus virginiana, Larix laricina, L. occidentalis, Picea Engelmannii, P. glauca, P. Mariana, P. rubra,*

Pinus Banksiana, P. contorta, P. echinata, P. Lambertiana, P. montana, P. monticola, P. palustris, P. ponderosa, P. resinosa, P. taeda, P. virginiana, Pseudotsuga taxifolia, Quercus sp., Sequoia sempervirens, Taxodium distichum, Tsuga canadensis, T. heterophylla.

Distribution. — British Columbia, Manitoba, Newfoundland, Northwest Territories, Ontario, Quebec, Yukon Territory, Alaska, Alabama, California, Colorado, Florida, Idaho, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, Ohio, Oregon, Tennessee, Utah, Virginia, Washington, Wisconsin, Wyoming.

Occurrence. — *Trametes odorata* most commonly attacks species of the genus Pinus. Although records exist of its appearing on Abies, its ally, *Lenzites saepiaria*, is much more abundant on this genus. Many field records, however, erroneously attribute rot caused by *T. odorata* to *L. saepiaria*, so that the fungus is actually more abundant than it might seem from published accounts.

Remarks. — Fungi usually found on conifers occasionally occur on hardwoods. For instance, there is an authentic record of *Trametes odorata* on an oak railroad tie. It is a well-known fact that many of the wood-destroying fungi found on hardwoods can be cultured on coniferous wood, and that coniferous fungi can likewise be grown on hardwoods in the laboratory. It is to be expected that such conditions may be duplicated in nature. This circumstance points to the relationship between *T. odorata* and *Lenzites trabea* and tends to explain some of the confusion that exists in the synonymy. According to Shope (5): "*T. protracta*, due to misinterpretations by earlier workers . . . appears to be very close to *Lenzites trabea* and probably is conspecific with it."

Poria ossea, sp. nov.

Type:

Poria ossea. Bayard, Florida. Coll. C. G. Lloyd. The C. G. Lloyd Mycological Collection 17453. Washington, D. C.

Fructificatio annua, irregulariter effusa, plus minusve 10 cm. in ligno, siccitate dura firmaque, inseparabilis, 12 mm. crassa; margine abrupto, primum sterili cito omnino fertili, pallide

ochraceo vel griseolilacino vel brunneovinaceo; subiculo distincto, plerumque minus quam 0.3 mm. crasso, albescentiochraceo vel pallide ochraceo; tubis minus quam 4 mm. longis, plerumque 3 mm. longis, non stratis, pallide ochraceis vel fuscoochraceis; aperturis $\frac{1}{5}$–$\frac{1}{3}$ mm. plerumque $\frac{1}{5}$–$\frac{1}{4}$ mm. dimetientibus, primum cum tubis concoloribus sed actione kali caustici obscure purpureis vel fuscopurpureis; basidiis 2-sporis, 11–20 × 4–5.5 μ; sporis hyalinis, 3–4 (5.5) × 2 μ; hyphis hyalinis, saepe ramosis septatisque, fibulatis, membrana tenui septatis.

Specimen typicum conservatum est in collectione Lloydiana, Washington, D. C.; legit C. G. Lloyd, n. 17453, in loco dicto "Bayard," Florida.

Fructification annual, effused for 10 cm. or more in irregular patches on bark or old wood, inseparable, up to 12 mm. thick, drying hard and firm; margin abrupt, sterile at first, becoming entirely fertile, "chamois" to "benzo brown" to "dark vinaceous drab"; subiculum distinct, mostly less than 0.3 mm. thick, "cream buff" to "chamois"; tubes up to 4 mm., mostly about 3 mm., long, not stratified, "chamois" to "Isabella color"; mouths 3–5, mostly 4–5, to a mm., concolorous with the tubes and turning "dull Indian purple" to "dark purple drab" with KOH; basidia two-spored, 11–20 × 4–5.5 μ; spores hyaline, 3–4 (5.5) × 2 μ; hyphae hyaline, frequently branched, thin-walled, often septate, clamp connections present.

Allied species. — *Poria ossea* is allied to *P. mutans* Peck, and *P. spissa* (Schw.) Cooke. The yellow color of *P. ossea* when dried will serve to distinguish it from the other species, which characteristically turn red upon drying. The spores of *P. spissa* are narrow, 3.5–4.5 × 1–1.5 μ, whereas those of *Poria mutans* are ellipsoidal or almost globose or ovoid, 3.5–5 × 2.5 μ. Both *P. mutans* and *P. ossea* become harder upon drying than does *P. spissa.*

University of Michigan

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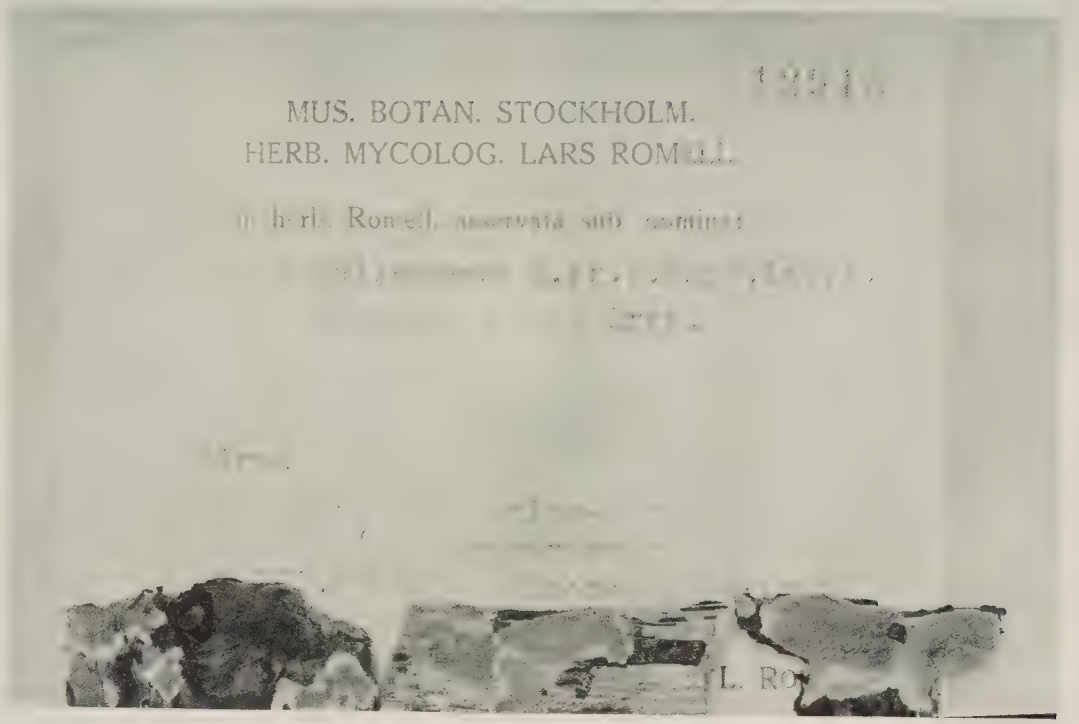
PLATES I–VI



Polyporus (*Poria*) *pallescens* Karst., *p. p.* Herb. Mycolog. Lars Romell, Stockholm, Sweden

FIG. 1. *Polyporus vulgaris subradiosa* on frondose wood, near Stockholm

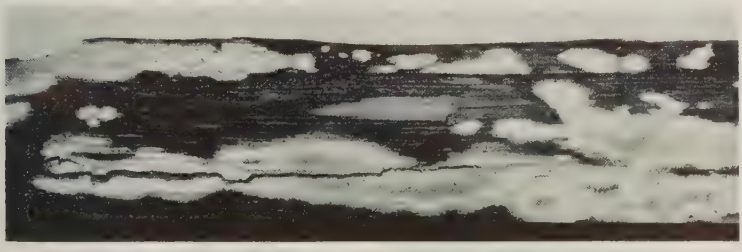


FIG. 2. *Poria vulgaris subradiosa* on coniferous wood. Det. Romell. Also named *Poria biguttulata* Rom.

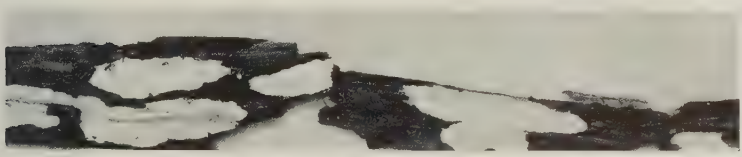


FIG. 3. *Poria vulgaris coniferarum*

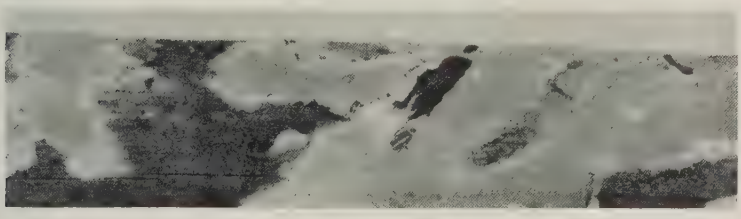
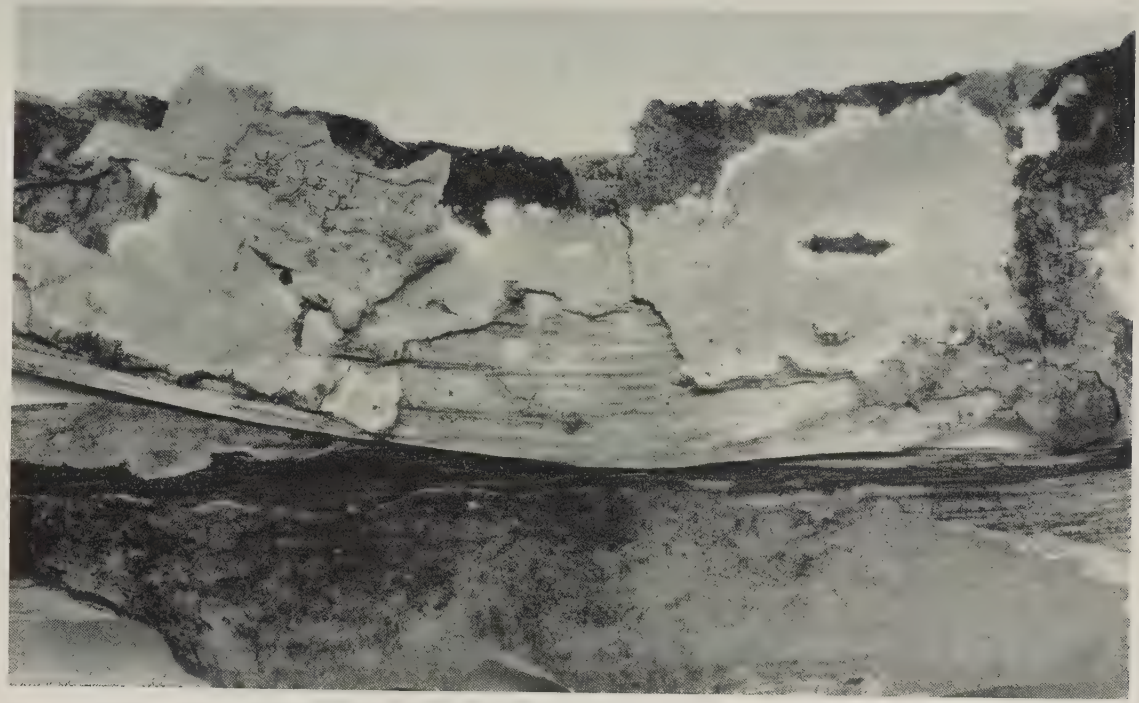
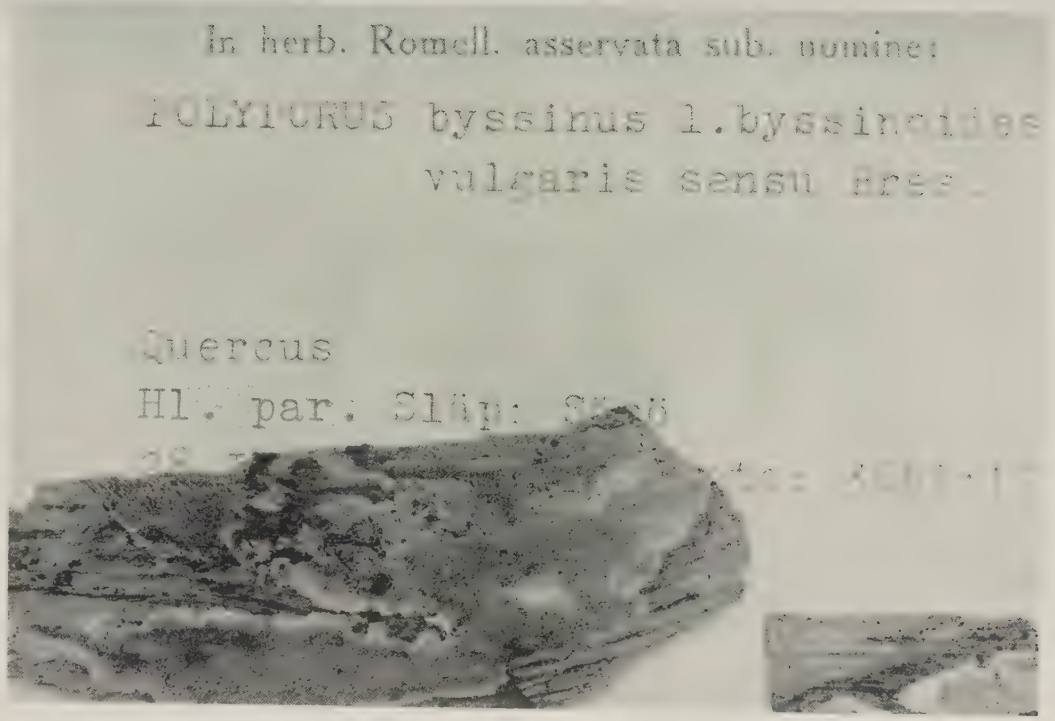


FIG. 4. *Polyporus vulgaris* f. *radiosa* on coniferous wood, near Stockholm

(All four specimens in Herb. Mycolog. Lars Romell, Stockholm)

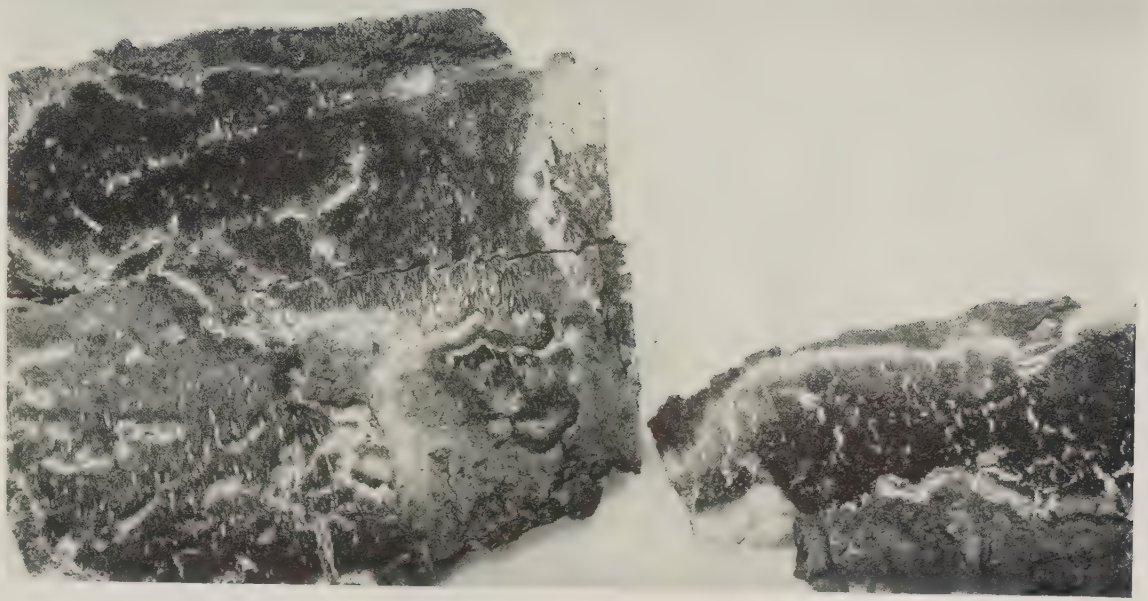


Polyporus byssinus Pers. on *Corylus avellana*, Sweden. This is Bresadola's interpretation of *Poria vulgaris* according to Romell. Herb. Mycolog. Lars Romell, Stockholm



Polyporus byssinus on *Quercus sp.* Herb. Mycolog. Lars Romell, Stockholm

Poria vaporaria on *Picea excelsa*, near Upsala, Sweden. Coll. Dow V. Baxter, det. Seth Lundell



Polyporus resinascens on *Populus tremula*, near Stockholm. Det. Romell. Herb. Mycolog. Lars Romell, Stockholm

THE INTEGRATION OF NATIONAL-FOREST AND COUNTY PLANNING

RALPH E. CROWELL

LAND-USE planning in one form or another is as old as history and the human race. It will continue as long as people are dependent on land. In Biblical times the shepherd drove his flocks from one grazing ground to another; the American Indian tribes had their hunting grounds and fishing waters and fought among themselves to retain them.

The United States Forest Service has been a manager of public lands since the passage of the Organic Act of June 4, 1897. This act recognized various uses of land, and provided for the interests of settlers, miners, and farmers located within the boundaries of the forest reserves, later called national forests.

The Forest Homestead Act of June 11, 1906, permitted homesteading of lands within national forests chiefly valuable for agriculture. The so-called Classification Act of August 10, 1912, directed the secretary of agriculture to select, classify, and segregate as soon as practicable all lands within the boundaries of national forests that were to be thrown open to settlement under the Homestead Law. This required that specific lands be classified as suitable for either farm crops or forest crops and was one phase of land-use planning.

Unified county planning by committees of local residents under the direction of the Extension Service of the Department of Agriculture represents the most recent and comprehensive step in the evolution of planning that was stimulated by conditions of the depression period. The reader is familiar with the mechanics and purposes of the unified or intensive county-planning procedures, and hence they will not be repeated here. The general consensus, shared by the author, is that this latest attempt to plan use of land by local people in coöperation with interested technical agencies and bureaus is a sound approach and is fundamental to any action program. After observing the process and assisting in the prepara-

tion of the county land-use plan during 1941 in two counties within the Huron National Forest the writer has only one regret — that the plan was not completed many years sooner. The collecting of facts concerning soils, population, natural resources, incomes, tax delinquency, and local governmental service costs for roads, schools, and other functions for the consideration of all interested groups and individuals, with their many diverse viewpoints, is the American way of government. It is an application of the democratic process under the guidance of the technician, who is available to advise on the technical phase of the program but does not dictate the policy of the plans.

It is true that the plan is not perfect, and the men who worked with it would be the first to recognize and admit its shortcomings. At times the members are unduly swayed by the arbitrary ideas of one of their number. Occasionally hope of personal gain influences the classification of certain lands. The county committee may be reluctant to adopt a uniform policy and iron out apparent discrepancies in the local classifications. It is probable that not all interests are represented in the proper proportion, and that agricultural viewpoints dominate.

Land-use planning was conducted in Oscoda and Alcona counties, parts of which are within the boundaries of the Huron National Forest. For the sake of brevity the remainder of the paper will be restricted to comments on the plan for Alcona County, which is a fair sample of northern Michigan counties.

Alcona County's population is 5,000; its gross area is approximately 313,000 acres, of which 269,000, or 86 per cent, are within the Huron National Forest. Of the 107,000 acres in public ownership 85,000 are federal- and 22,000 state-owned.

The land-planning committee classified 2,240 of the 85,000 acres of federally owned lands as primarily valuable for farm purposes, including grazing. Our responsibility as wild-land managers is to do what we can to translate the plan into action. Some of the farmers living adjacent to these lands need more pasture or additional areas for cultivation.

Existing legislation permits the exchange of national-forest lands that are suitable for farming for forest lands of equal value if such an exchange is advantageous to the government. The recommendations of the planning committee have resulted in the initiation of

transfers under the exchange procedures. In this way federally owned farm lands will be returned to private ownership where farmers now own or can purchase forest land to use as a basis for exchange.

The report for Alcona County brings out the fact that many pastures both privately owned and leased from the government are poor and need improvement to increase their carrying capacity. We are now working on an arrangement whereby the pastures leased from the government may be improved by a permittee with his own resources or by loans made by the Farm Security Administration and fertilizer obtained under the Agricultural Adjustment Administration program. All pasture-development plans are to be approved by the county agricultural agent if the pasture improvement is to be on government lands.

The land will continue to be leased to the farmer by the Forest Service until such time as he is in a position to acquire it through exchange, and such exchange will be at wild-land values, and not improved-land values.

It is expected that a considerable part of the federal lands classified for agriculture will not be in demand for development in the immediate future. As a rule, these lands are the more productive forest lands and support thrifty sapling or pole hardwood stands. It is planned to have them continue producing a forest crop until the need for agricultural use arises.

The land-planning committee also lists 5,520 acres in farms that are not suitable for arable farming, and 2,880 acres now in farms that are of doubtful value for farming. The Forest Service can help to place this acreage in proper use in its land-purchase or land-exchange program. The assistance of other agencies, such as the Farm Security Administration, will probably be necessary to work out the relocation of farmers from the poor to the good agricultural lands. Our attempts to date have not been very successful because of the limited amount of money the Forest Service can offer for this type of land and improvements. In addition, the owner usually needs financing when he moves to a new farm. The Alcona report shows that, in general, farmers do not have sufficient cleared acreage to make an economic entity. The Extension Service and the Farm Security Administration are assisting them to develop the proper economic unit.

The Alcona farmer depends to a considerable extent upon the

national forest for building materials, fuel, and other forest products. From sixty to seventy "sales at cost" ($1.00/MBM) are made annually to Alcona County farmers for fence posts, saw timber, and material for farm improvements. The forest management plan must integrate with the county plan.

Statistics show that the income of Alcona County farmers is lower than that of farmers in almost all the other counties in the state. To augment their income efforts are being made to secure better farm practices, increase the cleared land on each farm, improve pastures, and provide supplemental earnings by the harvesting of the timber crop. To assist in the development of the local timber economy the Forest Service sponsored the Au Sable Forest Products Cooperative Association, a coöperative engaged in marketing forest products. It was organized with the help of the Extension Service and financed by the Farm Security Administration. Attention is here called to the three bureaus of the Department of Agriculture that work jointly on this enterprise. If intensive county land-use planning has obtained no result other than that of bringing various governmental units together to work for a common purpose, it has achieved a highly desirable objective.

The coöperative is a marketing association that secures contracts for forest products produced by the members, finances stumpage when necessary, makes advance payments to members when they have forest products cut in the woods, and arranges for the trucking and loading on cars if a member does not have a truck.

Field representatives of the Forest Service (rangers and scalers) give the operators instructions concerning specifications for various forest products so that they will be marketable, advises them on the proper tools to use to increase production, such as one-man Swedish bucksaws instead of the conventional two-man saw, and tells them how to lay out strip roads and pile their products so that the trucks can pick them up. In this way the association aids in solving the small producers' problems of marketing, financing, and operating procedure. About fifty farmers are active members of the association and are supplementing their farm income by harvesting forest products, which are sold through the coöperative.

Alcona County's intensive plan is not sufficiently complete to enable one to prepare a report covering all uses. The initial planning has been to classify lands for farming, pasture, recreation, hunting,

and various public uses. The next step is to correlate the use of the lands classified to meet as well as possible the needs of the people. This is the action field in which the various bureaus of the Department of Agriculture must participate in conjunction with the local governmental units if the benefits of the plan are to be realized.

The United States Forest Service can and will assist (1) by adjusting its program so as to acquire by exchange or purchase those lands not suited to agriculture or higher private use, (2) by exchanging agricultural lands now in government ownership for non-agricultural lands as the need arises, (3) by providing a sufficient supply of forest products to meet the needs of agriculture and other local enterprises in preference to supplying outside industry, (4) by assisting in the development of methods whereby supplemental incomes can be secured by harvesting timber products and marketing them through coöperatives such as the Au Sable Forest Products Cooperative Association, (5) by providing employment in the development and protection of the forest, and (6) by giving full cooperation to other agencies in placing the plan into effect.

United States Forest Service
Huron National Forest
East Tawas, Michigan

HUNTER EXPENDITURES IN CHEBOYGAN COUNTY, MICHIGAN, DURING THE SEASONS OF 1939–40, 1940–41, AND 1941–42

JULIAN GRIGGS

AN INDEX of the value of game in the northern Michigan cutover area is afforded by the amount of money spent and earned in connection with hunting. A study that would measure this value in terms of sales of goods and services to hunters would be of aid in planning for the game resource and in expanding the income to be derived from it. The present paper is an analysis of data that were collected in Cheboygan County,[1] an area of 725 square miles in the northern part of the Lower Peninsula. The principal population centers are Cheboygan, with 5,600 inhabitants, Mackinaw City, with 900, and the villages of Indian River, Topinabee, Tower, and Wolverine. The transportation system is good. Three state highways pass through the county, and another touches it at Mackinaw City. Between it and the Upper Peninsula the State Highway Department operates a ferry service that connects with these automobile arteries after they have converged at Mackinaw City.

Because of many variables the selection of a county in which expenses of hunters might be regarded as typical proved difficult. Though no single county can give an overall picture, Cheboygan County was thought to be a fairly representative hunting area. Although the number of sportsmen hunting there was slightly less than the average number in the northern counties in the Lower Peninsula, it was a little above the average for counties in the Upper Peninsula. The percentage of hunters who were successful in killing a deer was less than in many Lower Peninsula areas, but the average kill of grouse and snowshoe hares was greater. Expenses are heaviest in

[1] This work was sponsored by the Game Division of the Conservation Department of the State of Michigan and by the School of Forestry and Conservation of the University of Michigan.

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localities where good hunting areas are situated close to towns. Since in Cheboygan County the best hunting is at a considerable distance from population centers, the expenses of those hunting in the county are less than might normally be expected. It is felt, however, that this deficit is offset by the income derived from the abnormally large number of hunters who pass through the county to take the ferry to the Upper Peninsula.

THE METHOD OF INVESTIGATION

The interviewing technique employed was similar to that used by Gordon to compute the expenditures of hunters in Washtenaw County, Michigan.[2] Sportsmen were questioned by the writer, and data on their Cheboygan County hunting expenses were recorded on form sheets. Some were given questionnaires, together with self-addressed stamped envelopes, to be filled in later. In this way further information was secured after the interviews. Often proprietors of cabins were able to itemize expenditures of sportsmen who came from other counties but were not available for interrogation.

In each northern county expenses are incurred by hunters who pass through it en route to their favorite hunting grounds as well as by those who hunt within it.[3] In the investigation in Cheboygan County sportsmen were classified as residents of the county and as nonresidents. A distinction was made between nonresidents who hunted in the county and those who merely drove through it during their trips after game.

Types of goods and services purchased by the different groups of sportsmen varied. Expenditures for travel by car and for ammunition and clothing were made by hunters in each of the categories, but only the nonresidents who hunted in the area paid for guide services. Some nonresidents and some residents bought materials and labor for building or renovating cabins, but, of course, none of the sportsmen who crossed Cheboygan County without

[2] Gordon, Seth, Jr., "A Sampling Technique for the Determination of Hunters' Activities and the Economics Thereof," *Journal of Wildlife Management*, 5 (1941) : 260–278.

[3] Expenditures of those who travel through Cheboygan are atypical with respect to state ferry fees (which are peculiar to that county and to one other) because they benefit these areas by providing employment for the local population. Inclusion of these fees (Table III), however, probably renders the total representative by offsetting the abnormally low expense of sportsmen who hunt in the Pigeon River and Black Lake State Forests.

stopping to hunt spent money for such items. In figuring the expenses of those who lived within the area studied the cost of board and lodging and of beverages and amusements was not included because such outlays would have been made had they done no hunting.

In computing expenses the schedule forms and questionnaires of the group of hunters interviewed were analyzed in order to get the average sum. This amount was then multiplied by the total number who hunted as a means of learning what they all spent. The methods of finding the number of hunters in the various groups were different. The number of county residents who hunted was secured by consulting the license records and by questioning those who hunted legally without a license, that is, farmers who sought small game on their own enclosed lands. The number of nonresidents who hunted in the county was computed from interviews, from questions asked of those who lodged sportsmen, from information procured in local papers, and from field observation. Michigan state ferry statistics were used in conjunction with interviews to find the number of sportsmen who drove through Cheboygan County on trips after game.

The group of sportsmen questioned was typical of the hunters as a whole. Representativeness was determined through the criteria of geographical distribution, age, and occupation. Where none were available, a test based on the standard deviation was made. Because of the small number of interviews the accuracy of expenses listed for nonresident duck and rabbit hunters cannot be assured. The reliability of all other data is high.

EXPENSES OF RESIDENTS

The average annual expense of Cheboygan County hunters within and outside the county during the seasons of 1939–40 and 1940–41 was $18.98, as is shown in Table I. Of this amount 85 per cent was expended within the county. The 2,350 sportsmen paid out a total of $44,600. Travel by car cost more than any other single item, and outlays for buying and caring for hunting dogs were the next highest items. Most hunters spent more for ammunition and for clothing and miscellaneous purchases than they did for guns. About 12 per cent of the purchases within the county were made in rural areas where dogs, second-hand guns, and camp improvements were the principal items.

TABLE I

ANNUAL HUNTING EXPENSES OF CHEBOYGAN COUNTY RESIDENTS FOR THE SEASONS OF 1939–40 AND 1940–41 *

Items	Number of hunters interviewed	Expenses in the county		Expenses outside the county	
		Average expense per hunter	Total spent by hunters	Average expense per hunter	Total spent by hunters
Travel by car	190	$4.21	$9,900	$0.87	$2,040
Hunting dogs	630	4.08	9,590	0.43	1,000
Ammunition	810	2.71	6,380	0.18	420
Clothing and miscellaneous items	810	2.49	5,840	0.21	500
Guns	810	2.34	5,500	0.73	1,710
Camp improvements	810	0.26	620	0.47	1,100
Totals	...	$16.09	$37,830	$2.89	$6,770

* 2,350 was the average yearly number of hunters for the period.

EXPENSES OF NONRESIDENTS OF THE COUNTY

More nonresidents than residents hunted in the county, and expenses incurred by the sportsmen from outside markedly improved the fall business conditions. The number of deer hunters was about twice the number of hunters of all other game species combined. Therefore the large-game season, November 15 to 30, was a period of intensive hunter spending.

In Table II the expenses incurred in hunting the four principal types of game are listed. The items that made up these expenses were camp improvements, beverages and amusements, board and lodging, travel by car, groceries, guide service, guns, ammunition, dogs, clothing, and miscellaneous purchases. Amounts spent by individuals depended somewhat on their annual incomes and on the number of days they hunted. Most grouse hunters earned higher salaries than the sportsmen in search of large game, and they expended 67 per cent more on the average. Ducks and snowshoe hares were hunted for shorter periods than other game, and hence costs were lower. As a rule, the duck hunter spent more than the rabbit hunter.

TABLE II

EXPENSES OF NONRESIDENT HUNTERS WHO STAYED IN CHEBOYGAN COUNTY AT LEAST ONE DAY AND ONE NIGHT DURING THE 1940–41 SEASON *

Game hunted	Number of hunters interviewed	Number of hunters	Average expense per hunter	Total spent by hunters
Snowshoe hares	8	40	$10.00	$ 400
Ducks	8	80	15.00	1,200
Grouse	55	275	22.54	6,200
Deer	330	830	13.50	11,170
Total	...	...	...	$18,970

* The expenses of those who hunted but who did not stay overnight are not included. Estimates based on field observations indicate that there were about 2,500 of these hunters and that they spent about $3,000 during the season. Thus expenses of all nonresidents who hunted in Cheboygan County amounted to $21,970.

Proportional costs to hunters for the several items varied with different types of sportsmen. Thus the large-game hunters spent 32 per cent of the total of $11,170 for camp improvements, 26 per cent for beverages and amusements, 24 per cent for board and lodging, 10 per cent for travel by car and smaller percentages for other items. Grouse hunters spent proportionally more for board, lodging, and travel by car, and less for camp improvements and beverages and amusements. The percentages of their total costs for these purchases were 26 for camp improvements, 14 for beverages and amusements, 27 for board and lodging, and 13 for travel.

EXPENSES OF HUNTERS WHO PASSED THROUGH CHEBOYGAN COUNTY EN ROUTE TO HUNTING AREAS ELSEWHERE

Only a few small-game hunters traveled through the county on their way to hunt elsewhere, but many sportsmen in search of large game did so. Most of them came north just before the deer season opened, and in 1940 many were caught in the November blizzard that caused interruption of the state ferry service for more than twenty-four hours. It forced sportsmen to delay at Mackinaw City, where their expenses were high while they were awaiting passage to St. Ignace. In 1941, however, the weather was mild and ferry serv-

ice continuous, so that no extra expenses were incurred. Table III shows that on the average hunters spent only 74 per cent as much as they had done in 1940, and that beverages and amusements cost them only 47 per cent as much. The total expenses of hunters were nearly as great as they were in 1940, however, because the number crossing the Mackinac Straits was 37 per cent larger.

TABLE III

EXPENSES OF HUNTERS IN PASSING THROUGH CHEBOYGAN COUNTY *

Items	Number of hunters interviewed		Expenses	
	1940	1941	1940	1941
Travel by car	1,983	1,159	$17,440	$17,680
State ferry fees	1,108	1,159	15,880	21,200
Food and lodging	1,983	1,159	14,640	9,090
Beverages and amusements	1,983	1,159	3,910	2,036
Camp supplies, ammunition, clothing, and miscellaneous items	1,108	1,159	845	890
Totals	...	...	$52,715	$50,896

* There were 20,700 hunters in this group in 1940 and 27,000 in 1941.

THE VALUE OF HUNTING TO THE COUNTY

One of the major problems of the trade with tourists arises from the shortness of the summer recreation period. Persons who cater to these seasonal visitors must make their living during a few months of the year or else supplement their income by other occupation in the winter and spring months. This condition is alleviated by utilization of the game resource, which attracts visitors who would otherwise come to the county only in the summer.

During the hunting seasons in question the average annual expenditures of hunters in the county amounted to $112,000, of which 66 per cent was brought in by sportsmen from other places. The remaining 34 per cent was spent by residents.

A LOOK AHEAD

The study indicates that it may be possible to expand incomes from the game resource indirectly through the sale of more goods

and services to hunters. They spend surprisingly little in rural areas, despite the fact that many of them room and board with farmers during their stay. Residents of the county might sell sportsmen more farm and other products. Articles that carry the aroma of the Northland might have an appeal to hunters. Maple sugar and appetizing preserves could be offered for sale.

Attractive wooden ornaments and objects that might serve some useful purpose can be made by hand with a minimum of tools. Tests by the writer have indicated that packboards with canvas packsacks attached are easy to construct. Such a beginning might lead to the establishment of a small woodworking plant capable of making things that sportsmen would buy. Experiments have shown that aspen, often considered a weed species, can be employed more than it is at present. Investigation at the University of Michigan is beginning to reveal that practical aspen products can be made locally with simple equipment.

The situation is one that merits further attention, and the study is being continued in an effort to find means of enabling residents to make better provision for sportsmen and thus increase the income derived from the game resource.

University of Michigan

PARTIAL CUTTING IN BLACK SPRUCE IN THE LAKE STATES *

RUSSELL K. LEBARRON

IMPORTANCE OF SPRUCE TIMBER

ONE of the more important remaining softwood timber resources of the Lake States is spruce, because of its inherent suitability for the manufacture of paper and because of the large volume obtainable, nearly seventeen million cords (2). The available statistics do not show the proportion by species, but black spruce (*Picea mariana*) undoubtedly far exceeds white spruce (*Picea glauca*) in both volume standing and amount cut.

Although extensive black-spruce stands occur on upland mainly because of this tree's peculiar seeding habits, which enable it to reseed after forest fires in much the same manner as jack pine (5), it is particularly at home in swamps. If one takes into account both spruce swamps and "spruce-fir" upland, nearly eight million acres in the Lake States are suited to the growth of black spruce. This amount is exclusive of muskeg and "Christmas tree" bogs, where the trees never attain merchantable size for pulpwood.

Some foresters have been inclined to disparage the management possibilities of black spruce because of its slow growth. It is true that it is a slow-growing species, and on the wetter bogs the trees never become large enough for pulpwood. Yet, if such nonproductive sites are eliminated from consideration, its mean annual growth, as computed from yield tables, is only about one third less than that of jack pine, which is ordinarily regarded as a fairly rapid-growing species (3–4). When one bears in mind that black spruce commonly brings over twice as much stumpage as jack pine, its true value becomes clearer.

Previous to about 1930 almost all logging of black spruce was by

* Assistance in computations was furnished by personnel of the Work Projects Administration, Official Project 165–2–171–483, Sponsor, Lake States Forest Experiment Station.

clear-cutting. Loggers favored this method for economic reasons, and even many foresters believed that clear-cutting was necessary because of the reputation spruce has for lack of wind-firmness. In 1931 the Lake States Forest Experiment Station made a survey of cutover areas in northeastern Minnesota which showed that black-spruce swamps, when clear-cut, had generally reproduced rather well and that residual trees overlooked by the loggers had increased their rate of growth considerably (1). Since that time numerous studies have been undertaken by the Experiment Station to learn the reaction of black spruce to various types of cutting, its seeding habits, conditions essential for its regeneration, and its ecological requirements. The material presented in this paper summarizes the phases of this project having direct application to the possibilities of partial cutting.

CUTTING EXPERIMENTS

During 1934 and 1935 two series of cutting experiments in black spruce were initiated in northeastern Minnesota. One dealt with a typical even-aged, 65-year-old upland stand of fire origin growing on a shallow loamy soil overlying a ledge rock formation. The timber contained a small percentage of jack pine and aspen, and a scattering of paper birch, red pine, and eastern white pine. The volume ranged from 25 to 35 cords [1] per acre in various portions of the area. The site quality is about medium. Owing to the heavy spruce overstory there was practically no low vegetation except hypnum moss (*Calliergon schreberi*) that formed a continuous carpet over the ground much like that in dense swamp forests. The other series of plots was situated in two adjoining bogs, where the depth of the peat ranged from one half to two feet. Here there was considerable variation in age, with the older trees as much as 180 years old. The volume amounted to 18 to 25 cords per acre. The site quality is below the "poor" grade given in a black-spruce yield table (4). The principal forms of low vegetation were hypnum moss, sphagnum mosses, and Labrador tea.

Three methods of cutting were applied in both the upland and the swamp series: (1) clear-cutting, (2) partial cutting, and (3) clear-cutting in alternate 100-foot strips. In addition, uncut plots were reserved for comparison. In the upland partial cutting 25 per cent

[1] All trees over 3.5 inches d.b.h.

of the volume was removed. The cut was composed of the larger trees and included nearly all the jack pine. This resulted in a residual stand of excellent appearance. In the swamp partial cutting 40 per cent of the volume was removed. In places where there was a fair distribution of size classes the cutting left a good residual stand, but where the trees were nearly all larger, and fewer, the remaining stand was open. The 100-foot alternate strip cutting was laid out with the strips running east and west, roughly parallel with the prevailing winds, and the ends of the strips were left closed. In an earlier test reported by Shantz-Hansen (6) 66-foot strips running north and south had suffered from wind. Hence in planning the present experiment it was decided to make the strips wider and parallel with the prevailing winds in an attempt to lessen damage of the type described by Shantz-Hansen. Since only trees large enough for pulpwood were utilized, a good many small trees were left in the cut strips after logging was completed.

RESULTS

Upland Plots

The trees on the upland plots were remeasured after seven growing seasons. It was found that the uncut plot had made a net gain in volume of 7 per cent, although there had been a 4 per cent decrease in the number of trees (Table I). All other plots had suffered serious losses. The partial cutting lost 27 per cent of the trees and 19 per cent of the volume; the clear-cut strips, 80 per cent of the trees and 69 per cent of the volume; and the uncut strips, 31 per cent of the trees and 24 per cent of the volume. The residual trees in the clear-cut strips were largely suppressed individuals below merchantable size, so that heavy losses there had been expected, but the damage to the uncut strips and partial cutting was disappointing.

A study of the causes of mortality offers some rather significant information. On the uncut plot 28 per cent of the mortality was caused by windbreak and windthrow. On the partial cutting wind damage accounted for 37 per cent. On the clear-cut strips wind caused 76 per cent of the losses and on the uncut strips 54 per cent. It is apparent that on the strip cuttings wind was a sufficiently important hazard practically to disqualify the method for use on exposed sites, regardless of the extent of injury from other causes. It should be noted that in the partial cutting wind caused only about one

third of the losses, and hence it was much less important. The cause of the remaining 63 per cent of the mortality was not diagnosed satisfactorily, but it was almost certainly related to the extreme drought conditions of 1934 and 1936 and to the generally subnormal precipitation which prevailed over northeastern Minnesota for several years. The upland partial cutting test should therefore be rated as indecisive with respect to postcutting mortality. Further tests should be made of the utility of partial cuttings in upland spruce during years of normal or near-normal precipitation, particularly with somewhat younger stands.

TABLE I

NET CHANGES IN VOLUME AND NUMBER OF TREES IN UPLAND PLOTS DURING THE FIRST SEVEN YEARS AFTER CUTTING

Cutting method	Volume per acre		Trees per acre	
	Cords	Percentage	Number	Percentage
Uncut plot	+ 2.2	+ 7	− 28	− 4
Partial cutting	− 4.4	− 19	− 171	− 27
Clear-cut strips	− 4.1	− 69	− 210	− 80
Uncut strips	− 8.2	− 24	− 246	− 31

Swamp Plots

The trees on the swamp plots were remeasured after six growing seasons. In general, the results were much more satisfactory than those on the upland (Table II). Volume increases ranged from 7 to 16 per cent, although there were slight decreases in the number of trees. The relatively large growth on the uncut plot (3 cords in 6 years) is undoubtedly a temporary fluctuation, and over a longer period the volume on this overmature stand should remain essentially constant. The gains on the partial cutting may be taken as real and significant because the most overmature and decrepit trees had been removed. The growth on this plot, 1.7 cords in 6 years, is not impressive, but considering the very low natural productivity of the site it probably represents about all the growth that can be expected after the initial improvement cutting. It is believed that better-quality swamps will give proportionately better results. Recent experimental cuttings made in coöperation with the Minnesota Forest

Service near Big Falls, Minnesota, should provide information on this point after a few more years (Pl. I).

In one of the partial cutting plots there is an excellent distribution of size classes that should insure continuous periodic cuttings of perhaps 5 cords every 20 years. The other sample of partial cutting has less favorable distribution of sizes, and may reach a hiatus after one or two additional cuts have been removed. But even here it is believed the partial cutting will have proved helpful, first, by getting some additional growth on the present stand of timber, and, secondly, by greatly shortening the period between the removal of the last of the present crop and the first of the next crop.

TABLE II

NET CHANGES IN VOLUME AND NUMBER OF TREES IN SWAMP PLOTS DURING THE FIRST SIX YEARS AFTER CUTTING

Cutting method	Volume per acre		Trees per acre	
	Cords	Percentage	Number	Percentage
Uncut plot	+ 3.0	+ 12	− 30	− 4
Partial cutting	+ 1.7	+ 16	− 10	− 2
Clear-cut strips	+ 0.2	+ 7	− 25	− 14
Uncut strips	+ 2.1	+ 9	− 35	− 6

The 40 per cent initial cutting (about eight cords per acre) was too heavy to obtain the highest rate of growth, since it depleted the growing stock considerably. It is likely that a 25 per cent or five-cord cut would have given slightly better results. In the present instance it was believed necessary to take out eight cords, partly to satisfy the demands of pulp cutters and partly to insure removal of all the most decrepit trees. Subsequent experience has taught us, however, that somewhat lighter cuts are adequate for the initial improvement cutting. Furthermore, loggers are being educated rather rapidly to lighter cuts on managed forests, so that today cuts of four or five cords of spruce per acre will find buyers in accessible localities when pulpwood prices are good.

None of the plots in the swamp series experienced severe mortality except the clear-cut strips, where only a scattering of small suppressed trees was left (Table III). Even there the mortality was not so serious as in the upland strip cuttings. About half of the losses

were caused by uprooting and breakage, the proportion being nearly the same for all plots. It has been observed on a number of recent timber sales on the national forests that light cuttings in spruce swamps have not suffered excessive mortality from wind or other cause. Preliminary results from the new Big Falls cutting experiments show the same thing. Swamp black spruce seems to be sufficiently windfirm to endure thinnings of 25 to 40 per cent.

TABLE III

MORTALITY LOSSES IN VOLUME AND NUMBER OF TREES IN SWAMP PLOTS DURING THE FIRST SIX YEARS AFTER CUTTING

Method of cutting	Volume per acre		Trees per acre	
	Cords	Percentage	Number	Percentage
Uncut plot	1.3	5	46	6
Partial cutting	1.0	9	32	7
Clear-cut strips	0.9	30	55	30
Uncut strips	1.6	7	50	8

Partial cuttings of the type being discussed should be regarded as only an initial improvement cutting designed to convert wild natural stands to managed forests. They are not comparable with formal silvicultural systems, which are usually intended to be repeated again and again. Many of our wild forests will require two or three improvement cuttings before they commence to display their highest productivity. The yield from thrifty, managed forests and the best silvicultural practices for such forests cannot be determined until existing forests have been improved by judicious cutting. In the meantime the general rules to be followed are:

1. Maintain a large volume of growing stock by refraining from too heavy and too frequent cutting.
2. Improve thrift and growth by removing the mature, slow-growing, and less windfirm trees.
3. Strive for better distribution of size and age classes in order to provide growing stock for future cuttings.

SELECTION OF TREES TO CUT AND TO LEAVE

An important problem of partial cutting is how to select the trees to cut and those to leave. Obviously it is desirable to leave the

younger or more vigorous trees, but can they be identified easily and accurately? There is some evidence that vigor in black spruce can be recognized with a fair degree of certainty. To determine whether vigor can be judged by external characteristics increment cores were extracted from 84 trees, chosen at random in a swamp stand, which had been classified as "progressive," "stable," and "regressive." The diameter growth by vigor classes, shown in Table IV, indicates

TABLE IV

Diameter Growth for the Period 1931–40 by Vigor and One-Inch D.B.H. Classes*

D.b.h. class in inches	Average d.b.h. growth in inches, 1931–40, by vigor classes		
	Progressive	Stable	Regressive
4	0.71	0.58	0.24
5	1.02	0.63	0.22
6	0.71	0.75	0.20
7	0.68	0.51	0.29
8	...	0.54	...
9	0.79	0.59	0.25
10	...	...	0.80
11	...	0.74	...
Average	0.78	0.62	0.33

* Basis 84 trees.

that vigor was estimated accurately. In general the trees ranked as "progressive" grew the best, and the "regressives" the poorest. The comparatively fast growth among the stable and regressive trees in the 10- and 11-inch diameter classes may need some explanation. Although they had a good record for past growth, these trees are now showing signs of decadence and will probably die soon. Further analysis of the borings revealed that, for the lower diameter classes, the less vigorous trees tended to be older (Table V).

In classifying the trees by vigor classes progressive trees were those judged to be thrifty and likely to maintain a good rate of growth during the near future; regressive ones were those which appeared to be growing slowly or were likely to do poorly in the future; and stable trees were the ones intermediate between the progressive

TABLE V

AVERAGE TOTAL AGE IN RELATION TO VIGOR CLASS AND DIAMETER CLASS

Diameter class in inches	Average age in years by vigor classes		
	Progressive	Stable	Regressive
4	66	91	118
5	85	110	140
6	100	114	109
7	136	132	151
8	...	130	...
9	142	134	146
10	...	...	(?) *
11	...	145	...

* Core too rotten to permit reasonably accurate count.

and the regressive trees. Assignment of the trees to these vigor classes was based largely upon the following characteristics:

1. *Dead tip (upper 1- to 5-foot portion of the crown).* — A dead tip is believed to indicate a distinctly unthrifty condition; the tree is likely to die soon.

2. *Length and density of crown.* — A long and dense crown is evidence of rapid growth.

3. *Appearance of bark.* — Gray, shaggy bark is a characteristic of old trees (usually over 100 or 125 years). Trees with this kind of bark are generally slow growers. Dark bark with small tightly attached scales is associated with younger and more vigorous trees. Cracks in the bark to accommodate larger diameters are evidence of growth.

It seems evident from the data on growth in relation to vigor and size classes (Tables IV–V) that diameter-limit cutting rules or the very similar "stick-limit" cutting, in which trees having more than a specified number of sticks are cut, will not make the most of the possibilities for removing the slow growers and leaving the fast growers. Such rules allow the cutting of many promising trees and prevent the cutting of poor ones. Furthermore, it has been found difficult to get pulpwood cutters to adhere to diameter-limit or stick-limit rules. They are paid according to the number of sticks, and hence they have a financial incentive to cut as many pieces as possible

with a minimum amount of strip-road construction. For the best results the trees should be marked in advance of cutting. Marking is not so expensive as might be expected. It has been reported by H. L. Sundling, of the United States Forest Service, that in recent years many thousands of cords of spruce have been marked in partial cuttings on the Superior National Forest at a cost of about 10 cents per cord. Such a cost, which amounts to from 50 cents to $1.00 per acre, depending upon the cut, is certainly a modest expense for insuring continued productivity of the forest.

ROTATION AGE

Some consideration has been given to the problem of the right age at which to cut swamp-grown black spruce. The study at Big Falls, Minnesota, mentioned previously, included the collecting of increment cores near the ground level to investigate the development of wood decay in relation to age. Stump cores in trees less than 85 years old contained no actual rot, although some stain was present; 34 per cent of the trees from 86 to 105 years in age showed advanced decay, 41 per cent in the 106- to 125-year class, 47 per cent in the 126- to 145-year class, and 71 per cent among trees over 145 years old. Butt rot in spruce is not a serious factor in loss of wood, because the decay seldom extends upward more than two or three feet, but it does make the trees susceptible to breakage by the wind. Before attempting to generalize on the relation of decay to age it will be necessary to gather samples in other localities, but in this instance rot appeared to begin weakening the trees appreciably at about 120 years. In upland black spruce butt rot begins considerably earlier. On such sites in northeastern Minnesota 60–70-year-old trees with decayed bases that have been broken over by winds are common.

THE PROBLEM OF DECADENT STANDS

The virgin black-spruce swamp forests of the Lake States include a large number of greatly overmature stands that represent a difficult problem for conversion to managed stands. The timber in them is low in stocking, and in many of them there is a decided scarcity of seedlings and saplings. The problem is further complicated by the frequent occurrence of a heavy growth of Labrador tea, which seriously interferes with reseeding. The situation is analogous to that in many overmature upland types, such as white pine, in which dense

growth of shrubs retards reproduction. Under natural conditions poorly stocked overmature black-spruce swamps would probably be reproduced eventually through the intervention of fires, which, by burning off the litter and shrubby growth, provide a good seedbed. Regenerating spruce swamps by burning is not directly applicable on managed forests, however. Burning before logging would destroy or seriously degrade much of the merchantable pulpwood and, further, could be carried out successfully only during hazardous fire weather, because forested swamps do not burn easily. A fire after logging is no help to reproduction because it destroys the seed scattered over the ground or enclosed in the cones lying in the slash. The question of proper silvicultural practice for decadent spruce swamps is, therefore, still an open one. They are not well suited to the partial cutting method recommended in this paper.

REGENERATION

In most kinds of stands it does not appear to be difficult to obtain satisfactory regeneration after light cuttings. Six years after cutting in the swamp plots in northeastern Minnesota, for which the growth data have been reported, different parts of the area had from 900 to 5,600 black-spruce seedlings and saplings up to 3.5 inches d.b.h. Much of this stocking was advance reproduction of seedlings and layers that were present before logging. Regeneration of partial cuttings is simplified by the continuing seed supply, which eliminates the necessity of getting reproduction at once. On the other hand, clear cuttings must be restocked before or at the time of logging if the land is to be maintained at a high level of production.

Some attention has been given to improving reproduction by disposing of logging slash in various ways. Repeated observations have shown that heavy accumulations of spruce tops, limbs, and peeling bark not only smother seedlings already present but also prevent the establishment of new ones. As soon as spruce limbs dry out, the needles fall, forming a thick dry carpet that remains intact, sometimes for several years, until it is overgrown with sphagnum moss. The obvious ways of preventing this condition are either by concentrating the slash on as small an area as possible or by burning it in piles. In a test conducted by the Superior National Forest on a moderately heavy partial cutting near Grand Marais, Minnesota, the results three years after logging were as follows:

Slash-disposal method	*Number of black-spruce seedlings per acre*
No disposal	1,133
Lop and scatter	1,983
Pile	2,867
Pile and burn	2,250

The differences in seedling establishment are not striking, but they do show a trend that is in general agreement with the theory. Larger differences would probably occur in clear cuttings, where the slash accumulation is heavier.

Partial cuttings in upland black spruce seem to restock satisfactorily, but there is a decided change in species composition. After several years the upland partial cutting described previously had 1,000 black-spruce seedlings, 520 aspen suckers, 360 paper-birch seedlings, and 120 mixed jack-pine and white-pine seedlings per acre. No balsam fir seed trees were present; otherwise this species would have reproduced vigorously. It is believed that the several species named above will make a silviculturally desirable mixture in which black spruce can be maintained as a reasonably important component by the use of discrimination in future stand-improvement cuttings.

SUMMARY AND CONCLUSIONS

The studies and observations on the effects of partial cutting in black spruce reported in this paper suggest the following conclusions:

1. Swamp forests in reasonably thrifty condition are suited to partial cuttings in which 25 to 40 per cent of the volume can be removed. The cut should consist of decadent and slower-growing trees.

2. The relative vigor of individual trees can be judged with a fair degree of accuracy by the condition of the crown and the appearance of the bark, which permits rapid selection of the correct trees to remove in partial cutting.

3. Regeneration in partially cut stands is likely to be satisfactory, although it can be improved by reducing the area covered with slash and bark, as by compact piling or by piling and burning.

4. Greatly overmature, open stands, with a heavy low cover of Labrador tea, are not suited to partial cutting. The correct silvicultural management for such stands remains a problem.

5. Partial cutting in 65-year-old upland black spruce resulted in very serious losses of volume. The volume of the trees which died as a consequence of injury by drought and wind exceeded the gain in volume made by the surviving trees. Further tests of partial cutting should be made in younger stands during periods of more nearly normal precipitation.

6. Upland stands are usually fire types which, after cutting, tend to convert to mixed forests containing a variety of species. It should be possible, however, to maintain black spruce as an important component of the stand by liberation and improvement cuttings.

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Black spruce swamp forest at Big Falls, Minnesota. When composed of trees of mixed sizes and ages such forests are well suited to partial cutting. The down tree in the foreground is evidence of approaching decadence

MANAGING FARM WOODLANDS OF THE OAK–HICKORY TYPE

ALLEN FRANK MONROE

INTRODUCTION

BECAUSE of lack of pertinent data foresters and others interested in the oak-hickory farm woodlands in southern Michigan have found it difficult to evaluate their utilization possibilities under management. It is easier to decide on a system of management for the more normally stocked northern hardwoods of Upper Michigan, where grazing has not been commonly practiced. Basal areas of 140 square feet per acre may be expected in the northern hardwoods, but the inventory in most of the oak-hickory type woodlands of Lower Michigan shows only a fraction of this area. The data gathered in these woodlands indicate an average basal area of 40 to 50 square feet per acre; areas of 80 square feet occur rarely.

Management of the average 18–20-acre woodland necessitates the solution of many problems that vary considerably with each farm. Woodland-management plans, in order to be effective, should form a part of the entire farm-management plan. However, before the integration of farm woodlands within the general management plan of the operating units can be accomplished, it is necessary to determine the factors bearing upon the management of the farm forests.

INVENTORIES AND CONDITIONS OF THE OAK-HICKORY FARM WOODLAND

An inventory of the timber found on 1058.3 acres representing 45 farm woodlands well distributed in northeastern Livingston and southwestern Genesee counties is given in Table I.

The poorly stocked woodlands carry a high percentage of aspen, sassafras, serviceberry, ironwood, and blue beech. Pasturing and overcutting have contributed materially to the high frequency of these inferior species.

Table I shows that only 3.7 per cent of the total number of trees

TABLE I

DISTRIBUTION OF TREE SPECIES ON FORTY-FIVE FARM WOODLANDS

1058.3 acres

Species		Number of trees				Percentage	Approximate number of standard cords. All trees	Approximate merchantable board feet. Trees 15 inches and larger d.b.h.
		Diameter in inches			Total			
		2–6	7–14	15+				
Red oak....	Main timber species	22,712	21,245	2,905	46,862	26.5	9,166.7	795,910
Hickory....		26,448	8,387	458	35,293	20.0	2,312.1	88,390
White oak..		22,867	10,063	1,296	34,226	19.4	3,688.6	294,893
Maple.....		9,093	4,822	441	14,356	8.1	1,481.1	124,151
Ash		7,727	3,435	191	11,353	6.4	1,164.1	43,177
Elm		6,347	2,583	504	9,434	5.3	1,396.5	143,988
Cherry		4,899	1,405	103	6,407	3.6	412.7	20,732
Aspen		3,027	1,281	8	4,316	2.4	231.7	...
Basswood ..		2,306	1,304	197	3,807	2.2	536.2	67,014
Swamp oak .		1,315	1,061	279	2,655	1.5	451.1	81,241
Sassafras ...	Species of secondary importance	2,049	145	1	2,195	4.6	35.5	...
Serviceberry		1,678	19	...	1,697		31.6	...
Ironwood ...		1,473	172	...	1,645		49.5	...
Yellow birch		454	147	1	602		50.2	...
Blue beech .		510	...	...	510		7.8	...
Beech		234	180	25	439		32.0	5,185
Willow		63	104	6	173		22.6	...
Tamarack ..		51	97	7	155		45.4	880
Black walnut		35	93	24	152		31.8	5,380
Black gum ..		74	44	24	142		9.3	1,697
Butternut ..		64	46	1	111		6.0	110
Black locust.		61	11	...	72		2.7	...
White pine .		17	50	...	67		5.4	...
Dogwood ...		44	...	...	44		0.3	...
Tulip		1	8	17	26		24.6	12,062
White birch .		13	4	...	17		0.5	...
White poplar		2	4	3	9		3.5	290
Red cedar ..		6	...	...	6		0.1	...
Mulberry ...		3	...	...	3		...	...
Total		113,573	56,710	6,491	176,774	100.0	21,199.6	1,685,100
Percentage..		64.2	32.1	3.7		100.0		
Per acre		107	54	6	167		20.0	1,592

Approximately 46 per cent of the red oak consists of black oak and Hill's oak; 75 per cent of the maple is soft maple; and 85 per cent of the ash is white ash. Burr oak is classed with white oak. Swamp oak is given separately, since it has a considerable local use for fence posts.

measure 15 inches or over in diameter. This represents 1,592 board feet per acre. According to the data collected, the amount of timber in saw logs grown in the average farm woodland is sufficient to cover only one half of the farm's lumber needs. It is apparent from these facts that the marketing of timber from such woodlands is not feasible. Nevertheless, a movement of a considerable volume of saw logs was observed out of the territory studied and to the local mills. Much of this timber is cut from the 10- to 15-inch diameter class,

TABLE II

Distribution of Basal Area per Acre by Species and Size Class

1058.3 acres of woodland survey

Species	Diameter in inches			Total	Percentage
	2–6	7–14	15 +		
	Basal area per acre in square feet				
Red oak	2.9	10.4	4.5	17.8	32.3
Hickory	2.4	5.6	0.8	8.8	16.0
White oak	2.9	5.4	2.2	10.5	19.1
Maple	1.2	2.4	0.8	4.4	8.0
Ash	1.2	1.9	0.2	3.3	6.0
Elm	0.6	1.6	1.1	3.3	6.0
Cherry	0.5	0.6	0.1	1.2	2.2
Aspen	0.3	0.4	...	0.7	1.3
Basswood	0.3	1.0	0.5	1.8	3.3
Miscellaneous	0.7	1.0	1.5	3.2	5.8
Total	13.0	30.3	11.7	55.0	
Percentage	23.6	55.1	21.3		100.0

which means harvesting of the growing stock instead of the increment. Marketing will be an important factor only in the exceptionally good woodlands, whereas in the average farm woods it will serve as an outlet for excess material, mostly fuel wood, removed during improvements.

The distribution of the basal area on the 1058.3 acres as presented in Table II shows that the 32.1 per cent of the total number of trees within the 7–14-inch group represents 55.1 per cent of basal area found in the average woodland. It is noticeable also that the basal area is larger in the 2–6-inch group than in the group over 15 inches.

These findings indicate the need of intensive management and silvicultural practices to bring about the desirable restocking of the farm woodlands. The bulk of restocking in the merchantable class will originate, in the near future, from the present 7–14-inch class. The actual 2–6-inch class is potentially more important than the 7–14-inch class, because of the desirable combination of basal area and the distribution of tree species. From the data shown in Table II it is evident, however, that restocking and the distribution of age classes will approach normal conditions only after a considerable number of years.

DISTRIBUTION OF THE FARM WOODLANDS BY SLOPE AND SOILS

Most farm woodlands are on the "back forty" or in some inaccessible location of the operating unit rather than on land that is not suited to agriculture because of the soils and topography. As a means of evaluating the influence of soils and slopes on the quality of stands 20 woodlands comprising 353 acres were classified, regardless of soils and topography, on the basis of weighted averages, into three quality classes, namely, good, intermediate, and poor. The data obtained are shown in Table III.

TABLE III

STAND CONDITIONS ON TWENTY WOODLANDS

Class of woodland	Trees per acre	Basal area per acre in square feet	Merchantable volume per acre in cubic feet	Total volume per acre in cubic feet	Volume of board measure per acre. Trees over 10″ d.b.h.	Annual increase	Increase		Canopy
							Per acre	Per year	
							Cubic feet	Board feet	
Good	197	78.3	1,231	1,597	6,527	3.4	49.4	195	0.8
Intermediate	119	62.5	926	1,108	4,576	3.2	37.5	142	0.7
Poor	113	52.3	679	883	3,798	2.8	24.5	105	0.6

The results in Table III were used as a yardstick, and 3,644 acres of woodlands distributed throughout the study area were classed as good, intermediate, and poor. The necessary soils and slope data were obtained from conservation survey maps.

The distribution of woodlands of various grades on the various slopes is shown in Table IV.

TABLE IV

QUALITY OF WOODLANDS ACCORDING TO SLOPES

Quality of woodland	Slope and area percentage					Total
	0–2	2–6	6–10	10–20	20 +	
Good	40.1	37.4	9.5	2.9	10.1	100.0
Intermediate	44.5	28.9	8.7	5.9	12.0	100.0
Poor	50.8	23.1	8.4	6.5	11.2	100.0
Weighted percentage of total farm woodlands on each slope	47.1	26.8	8.6	6.0	11.5	100.0

Table IV indicates that the frequency of good, intermediate, and poor woodlands is approximately the same on the various slopes; the slope, therefore, is not a significant factor with reference to potential quality of farm forests.

It was found that 71.5 per cent of good woodlands in the entire study area are on Miami and Hillsdale soils. These soils comprise 50 per cent of the wooded acreage, and only 7.9 per cent of the total woodlands are good. This indicates improper management, since the soils were capable of producing good woodlands. Other soils such as Fox, Bellefontaine, Oshtemo, Brookston, and Conover, along with Miami and Hillsdale, constitute approximately 80 per cent of the wooded area, but only 5.5 per cent of these woodlands are good. It is noticeable that none of the better woodland trees grow on the low, wet soils, such as Granby, Maumee, Carlisle muck, Edwards muck, Rifle peat, and Washtenaw. It is evident that regardless of slopes the Miami and Hillsdale soils rank highest as potential sources of timber production if the present lack in woodland management and silviculture can be corrected. Next in importance are the Fox, Bellefontaine, Oshtemo, Brookston, and Conover soils. On the wet soils intensive management and silvicultural practices are hardly justifiable under the present economic conditions.

MANAGEMENT AND SILVICULTURAL PROBLEMS

The easiest problem to solve is that of the protection of the woodland from fire and grazing. Most farmers realize that the pasturing of woodlands is a poor practice and are willing to fence out

livestock. Fire is not a serious problem in the woodlands of southeastern Michigan.

The present locations and conditions of the oak-hickory woodlands are the result of the lack of appreciation of land use and management dating back to the pioneer days. Proper land use should involve the gradual conversion of steep farm land to forests and the removal of woods from fertile, level, or slightly sloping land. Field study shows that a high percentage of the oak-hickory woodlands is on potential agricultural land. It also indicates that the better land produces the best trees. The existing woodlands, at least those on suitable locations and classed as good and intermediate, represent a capital growing stock that is valuable enough to be retained, and it should not be suddenly eliminated for the benefit of agricultural crops.

A question often raised is, What can be done to improve the oak-hickory farm woodland? In some instances protection answers the question, but we frequently find that protection alone will not suffice. Some thin and "sod-bound" woodlands may require interplanting to obtain a good stand of adapted trees in minimum time. In other woodlands, however, the natural reproduction obtained after protection has given far better results than the planting. It has been observed also that where mineral soil has been exposed by contour furrows adjacent to tree-planting areas, the natural reproduction is more satisfactory than on sites with unexposed mineral soil. This indicates that furrowing or disking in existing woodlands will have a positive influence on restocking.

Most of the cuttings needed consist of salvage and simple improvement of existing stands of timber. No harvest cuttings will be practicable for some time to come. The value of proper cutting has been proved on several check plots on and adjacent to improved areas under the same soil conditions. On the Kerber farm in Fenton Township the basal area increased by 1.7 per cent on an untreated area and 3.2 per cent on the treated one. Five standard cords of fuel wood out of a total of approximately 25 cords were removed from one acre during the improvement cutting. The growth of the remaining trees exceeded the total growth of the check plot by approximately 0.1 cord. On the Miller farm in Hartland Township the increase of basal area was 3.1 per cent on the untreated area and 3.3 per cent on the improved one. This woodland contains larger

trees and did not make so quick a response, but present indications point to growth as favorable as that in the Kerber woodland. Nine and three-tenths standard cords of wood and 700 board feet of saw logs were removed from one acre. This left approximately 17 standard cords and 2,400 board feet of saw logs per acre. There is every indication that proper management and cutting will be beneficial to most of the woodlands in the area.

CONCLUSION

1. The present woodlands of the oak-hickory type in southern Michigan are not properly stocked.

2. They contain a great deal of low-grade material and a relatively small number of merchantable trees.

3. Most of the soils studied will sustain, under management, economically justifiable woodlands, regardless of topography.

4. Woodlands have a definite place in the land use and economic patterns of farms.

5. Management and silvicultural field tests have positively demonstrated that oak-hickory farm woodlands will respond to suitable treatment.

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A STUDY OF THE SPREAD OF FOREST COVER INTO WILD-LAND OPENINGS

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THE rate of spread of forest cover into wild-land openings presents a problem of vital interest to public agencies dealing with game and forest management. There is definite need for a better knowledge of the return of forest vegetation into man-made openings so that we may know what to expect in the way of openings necessary to meet game requirements in 25, 50, or 100 years, and may have a guide to aid us in planning future planting programs.

Ecologically the study involves many factors, of which the three principal ones are the type of cover, the type of soil, and the type of opening, i.e. how and when it was formed. There must be considered, in addition, the competing vegetation, the availability of seed, the moisture requirements and tolerance of the tree species, the nature of the original forest cover, the age and composition of the surrounding forest, and the size of the opening.

A complete correlation and integration of all these factors would require a more intensive investigation than was undertaken by the writer. In this study an attempt was made to get only a general picture of the rates at which openings in various wild-land types have closed in the past, roughly, what percentage of them are still open and how fast they are closing. This paper will deal primarily with a discussion of the methods employed and will present very general results and conclusions.

METHODS OF STUDY

The first method of approach to the problem was the comparison of old photographs with recent ones. In the case of aërial photographs the interval of eight or nine years between the two sets available was too brief and the scale of the pictures too small for changes to be readily discernible; hence little positive information could be gained. The comparison of old ground pictures, made fifteen to twenty-five years ago, with those just taken from the

same locations proved to be very satisfactory and presented undeniable proof of changes that had or had not occurred over a period of years.

Another important part of the study was the examination of many individual openings in various types of cover and on various types of soil. Information on the history of these areas was obtained either from evidence on the ground or from local people. On the basis of the time elapsed since the opening had been created and its present condition so far as stocking was concerned, it was often possible to predict when the opening might be completely taken over by trees. Openings of many sizes were studied, ranging from an acre or less to more than a section and including burned-over land, cutover land, and abandoned farms. In this part of the work much valuable information was obtained on the effects of forest composition, ground-cover competition, soil, and past history on the rate of closing.

With these data as a background the next part of the study was undertaken, namely, to determine by a survey the extent of the openings on various soil types and in various cover types, and to show, so far as possible, how rapidly they were closing. For this purpose a strip-line transect type of survey was employed. Wildland areas were selected at random from soil maps in as many major soil types as possible. These areas were then traversed by car, and notes were taken on the cover composition, tree ages, history, and extent of the various cover densities observed. The smallest distance which could be recorded with any accuracy on the speedometer of the car was 0.05 of a mile or, roughly, 250 feet. Therefore any change of cover or density that did not approach 0.05 of a mile in extent was considered merely a part of the surrounding area, and was not treated as a separate piece.

Openings were classified according to tenths of density of cover. The densities started with 0, which applied to areas having no trees or established reproduction. The next gradation was 0+, in which there were widely scattered trees or trees moving in around the perimeter, but not enough to occupy one tenth of the available space. From there the densities increased in even tenths according to the estimated space occupied by the crowns.

The age of an opening was considered to be that of the oldest trees that had come into it since its creation. Age groups were set up to

cover ten-year intervals, with the exception of the first, which was 0 to 5 years. The rest ran 6 to 15 for the 10-year class, 16 to 25 for the 20-year class, and so on to the 60-year class.

Predictions of the length of time required for an area to close were divided into three groups: up to 25 years, 25 to 50 years, and over 50 years, with an extra group in which nothing could be forecast, marked simply X. These estimates were based on the time required to reach a 0.7 density, after taking into account the present density, the size of the area, the age classes represented, the reproduction present, and the availability of seed that will reproduce under existing conditions. A density of 0.7 for the purposes of this study was regarded as closed.

Areas to be cross-sectioned were selected from Land Economic Survey soil maps and from the land-type maps prepared by the Conservation Institute at Michigan State College. Wherever possible, straight roads were followed in order to get better cross sections. The strips were approximately four chains wide, two chains on each side of the road. Where the cover on the two sides of the road differed for any considerable distance information was recorded separately for each side. Conditions on both sides were usually the same, however, for most of the traveling was done on third-rate forest roads or worse.

RESULTS

In the manner described above 470 miles of strip line were covered in northern Michigan. Information was gathered on twelve major soil types, the total area of which represents over five million acres of northern Michigan land. Sixty-five per cent of the sampling was on the light sandy pine-oak soils, and 35 per cent on the loamy sands and sandy loams of the hardwood country.

In working up the data four general soil groups were made by combining soils of similar character. For the pine-oak type of cover these were the "pine-plains" group composed of Grayling and Rubicon sands, and the "oak-hills" group, which was Roselawn sand; for the hardwood type of cover the groups were the "loamy sands" and the "sandy loams." Densities were likewise grouped into "open," consisting of 0 and 0 + stocking; "poorly stocked," consisting of 0.1, 0.2, and 0.3 densities; "medium-stocked," consisting of 0.4, 0.5, and 0.6 densities; and "well stocked," 0.7 and over.

The data were compiled separately for each of the three types of openings — burned-over land, cutover land, and abandoned farms. A more detailed discussion will be given of the burned-over type than of the other two, about which only general statements will be made here.

Burned-over Land

Burned-over land comprised 80 per cent of the total area sampled, making up nearly nine tenths of the pine-oak land and two thirds of the hardwood land. By combining the data for all species and all soil groups many interesting trends can be shown. For example, 14 per cent of the land that burned at least 20 years ago is

TABLE I

Percentage of Twenty-year-old Aspen in Various Density Classes on Burned-over Land

Density of stocking	Pine-oak cover		Hardwood cover	
	Pine-plains soils	Oak-hills soils	Loamy-sand soils	Sandy-loam soils
Well stocked.....	3	32	9	36
Medium stocked ..	18	40	39	29
Poorly stocked	68	21	37	27
Open	11	7	15	8

still open, and an additional 36 per cent is poorly stocked, which makes a total of 50 per cent either open or poorly stocked after 20 years. After at least 30 years since the burning 11 per cent is in the open class and 26 per cent poorly stocked, making a total of 37 per cent in these two classes. This is a gain of 13 per cent in 10 years, or, in other words, 13 per cent moved out of these two low-density groups in the ten-year period.

On the other hand, 31 per cent of those areas burned at least 20 years ago and 34 per cent of those burned at least 30 years ago were in the well-stocked class, which indicates that only 3 per cent had moved into this well-stocked class in 10 years.

Comparisons of the rates of closing-in on various soil groups also show interesting results, many of them fairly well known in a general

way to observers of wild-land types. Let us take, for example, aspen (since it occurs on all four soil groups) in the twenty-year age class on burned-over land. Table I gives the present stocking of these lands on the various soil groups. It can be clearly seen from this table that the better forest soils have closed more completely in the twenty-year period.

Another example of comparisons that may be made is found in Table II, which compares the estimated rates of closing *in the future* for the same twenty-year age class of aspen on burned-over land. Figures here represent the percentages of twenty-year-old aspen type

TABLE II

Percentage of Twenty-year-old Aspen Stands on Burned-over Land Expected to Close within Various Periods

Rate of closing in years	Pine-oak cover		Hardwood cover	
	Pine-plains soils	Oak-hills soils	Loamy-sand soils	Sandy-loam soils
0–25	11	50	43	62
25–50	70	38	31	26
Over 50	17	3	24	12
X	2	9	2	0

in each closing group. This includes, of course, only those areas with densities of less than 0.7, those of 0.7 and over being considered already closed.

Here again the reactions on the better soils are clearly presented. The large percentage for the oak hills (Roselawn sand) type under "X" is due principally to the many pockets and depressions in these hills that apparently are kept open by frost.

Though the percentages in the two tables are not to be accepted as absolutely accurate, they nevertheless serve to indicate very definite trends.

Information of the same type as that presented in the tables can be set forth for the other principal cover types and age classes. A comparison on the same basis of all age classes and cover types combined reveals the same general trends as for the twenty-year aspen stand.

Nearly three fourths of the burned-over areas sampled were in the 20-, 30-, and 40-year age classes, hence more reliance can be placed on the data in these classes than in those above and below.

Most of the burned-over areas that are well stocked and many that are medium-stocked are essentially even-aged, the result of the initial spurt of sprouting or seeding immediately after the fires. Many of the poorer soils probably lacked the capacity to support most of the seedling reproduction after it germinated; hence these areas contain only scattered trees; and without fires to stimulate sprouting of certain species, or to create better seedbed conditions, they must close up by the long, slow process of normal root sprouting. Measurements made on several clumps of aspen spreading by root suckering show that the rate of spread is approximately two feet per year in one direction. Similar measurements for pin cherry reveal that its rate is approximately two and one-half to three feet per year. The soil type made no appreciable difference. At this rate there are many areas of not over forty acres that would require over two hundred years to fill in were the spread to be by sprouting alone. What other factors might interfere cannot be predicted.

Unburned Cutover Lands

Cutover lands that have not burned since logging comprised approximately 15 per cent of the total area sampled, representing 3 per cent of the pine-oak type and 26 per cent of the hardwood type. Most of the cutover lands in the pine-oak cover type were jack-pine areas on the pine-plains soils. In general, under the clear-cutting practice usually followed on privately owned land of this type the areas are slow to come back, but all appear to be making some headway. Jack pine, cherry, and oak are the principal species coming in. Sod competition is apparently responsible for most of the delay.

So little cutover land on the oak-hills soil type was sampled that no reliable comparisons of closing-in rates can be made. It may be said, however, that the rates would depend largely on the amounts of oak and aspen that were cut and thus would sprout, the availability of red-pine and jack-pine seed, and the nature and completeness of the ground cover.

Little need be said about the closing-in of hardwood areas after cutting, since in nearly all of them hardwoods rapidly reoccupy the sites by sprouting from vigorous stumps or by the growth of ad-

vanced reproduction present before the cutting. Two thirds of the areas clear-cut ten years ago were in at least the 0.5 density class and were closing rapidly. Over 90 per cent had reached at least a 0.7 density twenty years after cutting. It appears that those hardwood areas that were not well closed up within twenty years after cutting had originally very little advanced reproduction and were composed principally of large mature trees, the stumps of which rarely sprout. Little difference was noted between the rates of closing on the loamy sands and on the sandy loams in the hardwood cutovers.

Abandoned Farm Land

Approximately 5 per cent of the total area covered was classed as abandoned farm land. This type of land was frequently difficult to determine, particularly on jack-pine plains, and possibly some of the land which was included as "burned-over" may have been farmed or pastured. Much of it, covered with grasses and having perhaps a few scattered trees, was burned over after abandonment, and filled in quite rapidly and completely with jack pine or aspen. Certain abandoned farm areas in hardwood country at present containing heavy sod and scattered elm trees may possibly have been pastured after the timber was cut. Since cattle do not like the rough leaves of the elm, this species was left to grow unmolested while maple and many other species were browsed out. An area was classed as burned-over, however, unless it could be definitely established as old farm land.

In the pine-oak areas 44 per cent of the abandoned farm land was closing so slowly that no attempt could be made to predict when it might be closed. Jack pine, red pine, cherry, and aspen were doing most of the pioneering, and there was little difference between the rates of closing on the two soil groups of this type.

In the hardwood areas 80 per cent of the farm land sampled was in the unpredictable class. Heavy sod, grasshoppers, scarcity of pioneer species in the surrounding cover, all contribute to make the process of closing extremely slow. There appears to be little difference between the rates of closing on loamy sands and sandy loams since heavy sod, which hinders seed germination, rapidly takes over the areas on each type, and the pioneer species spreading by root suckers make the same slow progress. It appeared that many of these areas would remain open indefinitely.

SUMMARY AND CONCLUSIONS

Though many areas and soils have not been included in this report, nevertheless those in northern Michigan about which there is most speculation have been, at least in some degree. One particular group of soils, which did not fit into either the dry pine or the hardwood soils, but which represents a considerable area, is the wet sandy-plains group, composed principally of Saugatuck sand and Newton loamy sand. In general, the cover on these soils has closed up rapidly since the areas were burned; the present cover is chiefly aspen and willow, with cherry and white birch in spots. Many small islands of drier ground are still open and are closing very slowly. They usually have a over of heavy sod, which hinders seeding.

In connection with the upland soil types, which were the principal subject of this problem, it can be said in general that the period of rapid natural closing-in of the old burned-over areas not already partly stocked is past. It is reasonable to assume that areas of any size that have lain virtually open for the past twenty or thirty years are not going to close in another twenty or thirty years. It is true that, as time goes on, more seed will be available from maturing trees on and surrounding the openings, but, barring fires, the ground cover is not going to be any more receptive to seed germination. The restocking of large areas by a normal process of root sprouting is extremely slow and uncertain. Where there is at present a scattered stocking of trees representing many age classes, including young seedlings, it is reasonably certain that the process of seeding will continue, and the area will eventually close in. Where the area has widely scattered trees all of one age, a condition found in many oak-sprout stands, it is difficult or impossible to make any prediction.

With only a little more than 25 per cent of the sampled area at least 0.7 stocked, 75 per cent is in various stages of closing or is entirely open. In the medium-stocked group, representing 25 per cent of the total area sampled, 75 per cent will apparently close within 25 years, and 20 per cent in between 25 and 50 years. The remaining 5 per cent will require over 50 years.

Of the areas poorly stocked at present, representing 33 per cent of the sample, approximately 20 per cent will close in 25 years or less, 50 per cent in 25 to 50 years, and 25 per cent in over 50 years. The remaining 5 per cent will possibly remain as it is indefinitely.

Of the areas that are now essentially open, i.e. less than 0.1 density, representing 15 per cent of the total of all classes of openings, cover types, and soils sampled, present indications are that nearly 50 per cent will require over 50 years to close, and 40 per cent will remain open indefinitely.

By combining the open and poorly stocked groups, which represent approximately 50 per cent of the area sampled and which are the areas of most interest, it is found that 15 per cent will close within 25 years, that 40 per cent will close in 25 to 50 years, and that 45 per cent will require well over 50 years or will remain open indefinitely.

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